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ABSTRACT

GRADES OR AGES: Grade 7. SUBJECT MATTER: Science. ORGANIZATION AND PHYSICAL APPEARANCE: The introduction describes the development of the junior high school science program. The main text is divided into three phases: Processes and Skills, Developing a Model of Matter, and Human Structure and Function. Phase I contains two subcategories: Rocks and Minerals, and Insects. The manual is lithographed and spiral bound with a hard cover. OBJECTIVES AND ACTIVITIES: Objectives are given before each section and activities are found under Teaching Suggestions. INSTRUCTIONAL MATERIALS: The text contains references for the teacher in each section. Four student manuals on rocks and minerals, insects, a model of matter, and living systems are included. STUDENT ASSESSMENT: Sample assessment tasks are included in the Teaching Suggestions. (BRB)

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Junior High School Science
A Manual for Teachers

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A SEARCH FOR STRUCTURE

Grade Seven

BALTIMORE COUNTY PUBLIC SCHOOLS

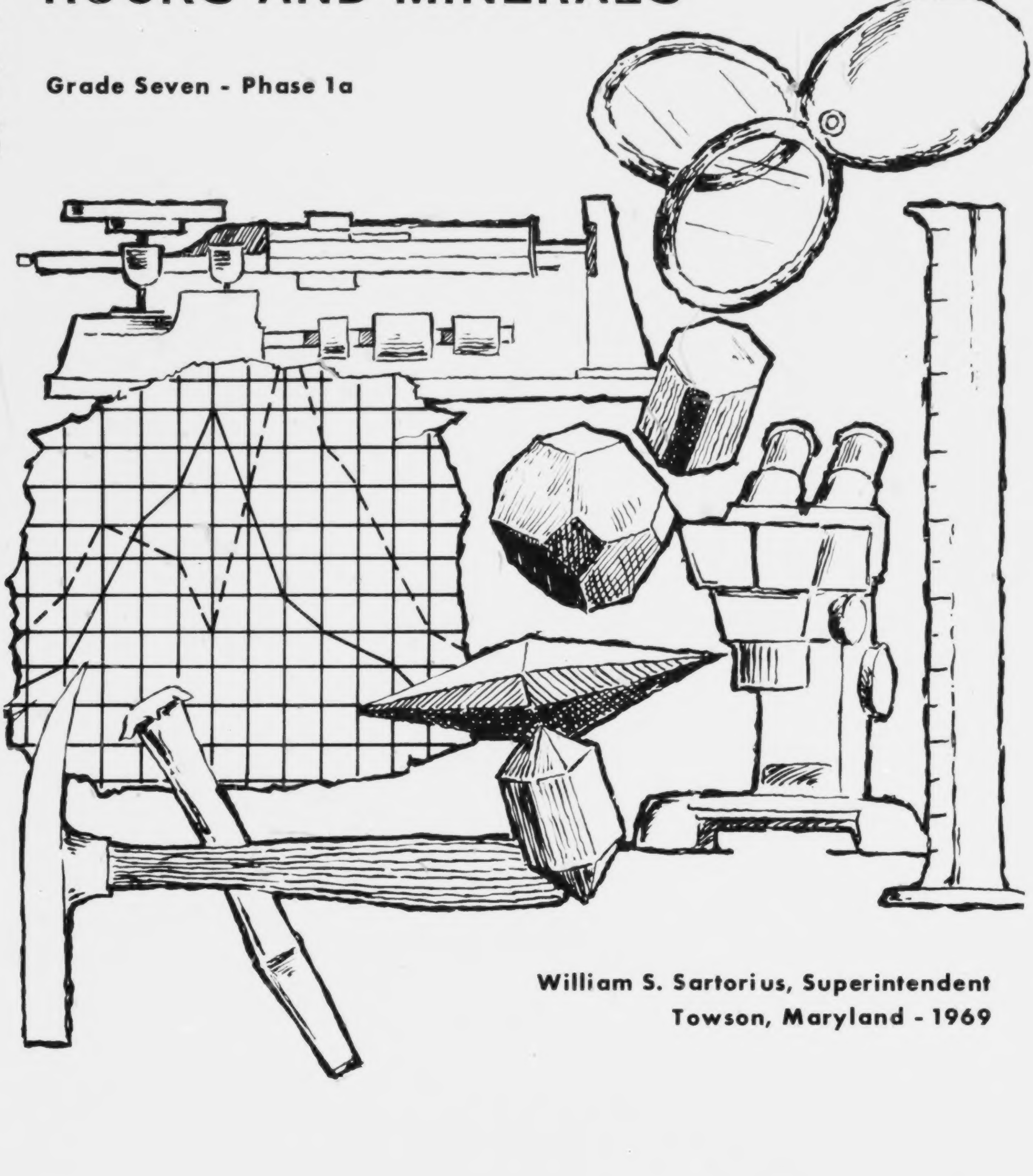
ED 072042

BALTIMORE COUNTY PUBLIC SCHOOLS

A STUDENT MANUAL FOR
JUNIOR HIGH SCHOOL SCIENCE

ROCKS AND MINERALS

Grade Seven - Phase 1a



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TO THE STUDENT

What is science? Perhaps you might answer by saying that exploring space is science. Or that inventing new machines is science. Or that experimenting with new cures for diseases is science. These answers are certainly not wrong, but each is only partly correct. Science is indeed a matter of exploring, of inventing, of experimenting. These are things that scientists do. There are other things that scientists do - for example, observing, measuring, verifying, hypothesizing, and others that may be familiar or unfamiliar to you.

Briefly, we can say that science is a way that people have developed for getting trustworthy information about all the objects and events around us. It begins with observations that can be checked by many people. And it leads to big ideas that explain how the world and the universe work.

Scientific knowledge is increasing rapidly. But the methods by which new knowledge is found have changed surprisingly little. Modern scientists deal with problems in much the same way scientists have gone about their work for several centuries. Of course modern scientists have many more instruments to help them make accurate observations and they have computers to help them solve problems.

You have no doubt yourself used methods of science to solve problems, probably without realizing you were doing so. You look at things, listen to them, smell them, and touch them. You discuss such observations with your friends, sharing your observations, and comparing yours with theirs. You may check your observations by reading what others have written about their observations. You make guesses about things you do not understand. And then you check your guesses by looking, listening, smelling, touching, discussing, and reading some more. When you think you have gathered enough information about a problem you decide on a possible answer. The scientist would say that you have observed, hypothesized, collected data, and come to a conclusion. These are some of the processes of science.

This year, you will learn to make better use of the processes of science. You will discover much knowledge that will be new to you. You will also use scientific methods to communicate your knowledge to others. And you will learn some basic principles of science that will help you understand how scientists explain the natural world. The science course you are about to begin is called "A Search for Structure." Most of your class time will be spent in laboratory work: conducting investigations, collecting data, recording data, and discussing your findings with others. This is not only a useful way to study science but, as noted before, it is also the way in which scientists themselves work.

In Phase 1 of this course you will develop scientific processes and skills that you can use throughout your study of science. You will learn to observe carefully, to use instruments to extend the powers of your senses, to organize observations or data in charts and graphs, to evaluate data to see what it indicates, to invent ideas that explain the data, and to experiment in order to test your ideas. By the end of Phase 1 you should be able to make clear statements about what you really observe. You will not be quick to answer a question until you have carefully gathered and looked at the evidence that relates to it.

In Phases 2 and 3 of the course you will reuse the skills you have gained in Phase 1 to study, first the structure of non-living things, and then the structure of living organisms.

OBSERVATION

What you know of your world comes to you through your senses. Here you are asked first to use your senses to make your own observations and then to interpret or make judgments about what you have observed. See if you can tell when you use only your senses and when you use judgment as well.

MATERIALS

5 shoeboxes

PROCEDURE

Near each box is a set of directions. Follow the directions exactly. Record your observations in the space below.

STATION	OBSERVATIONS
1	
2	
3	
4	
5	

OBSERVING PLANET G

A CLOSER VIEW OF PLANET G

You will see a set of six slides that show more views of Planet G. These pictures were taken much closer to the surface of the planet than were the pictures you saw before. What additional observations about Planet G can you make by studying these pictures?

MATERIALS

set of slides

slide projector

PROCEDURE

1. Study the six slides. In the chart below, list the observations you make from each slide.

Slide #1	
Slide #2	
Slide #3	
Slide #4	
Slide #5	
Slide #6	

41

2. When you have finished viewing the pictures carefully reread each statement in your chart. Do any of the statements contain ideas that go beyond what you actually saw? Circle any such statements.

3. Now work with another student to recheck the identification of statements that are not observations. Discuss any disagreements and make corrections where it seems necessary.

INTERPRETATION

1. How do your observations of these pictures compare with those you made from the film loop?

2. How might you account for differences between your new observations and observations made from the film loop?

3. Using everything you have learned so far, describe Planet G.

SURFACE SAMPLES FROM PLANET G

So far, all observations of Planet G have been made from photographs. An additional probe of the planet brought back actual samples of the planet's surface. What additional information do these surface samples give you about Planet G?

MATERIALS

surface samples

PROCEDURE

1. Examine each sample and list your observations.

	Observation
Sample #1	
Sample #2	
Sample #3	
Sample #4	
Sample #5	
Sample #6	

2. Can you see any way to put the samples into groups? If so, list the samples in groups here.

3. Give reasons for placing your samples in each group.

4. List the groups from Item 2 on the chalkboard, but do not give your reasons for the groups.

INTERPRETATION

Did all teams group the materials in the same way? How do you account for this?

USE OF INSTRUMENTS

In the seventeenth century man discovered new wonders that had been invisible to him before. These discoveries were made possible through the invention of magnifying instruments that made use of glass lenses. By using a simple magnifying lens you can learn how to make and interpret observations of very small objects.

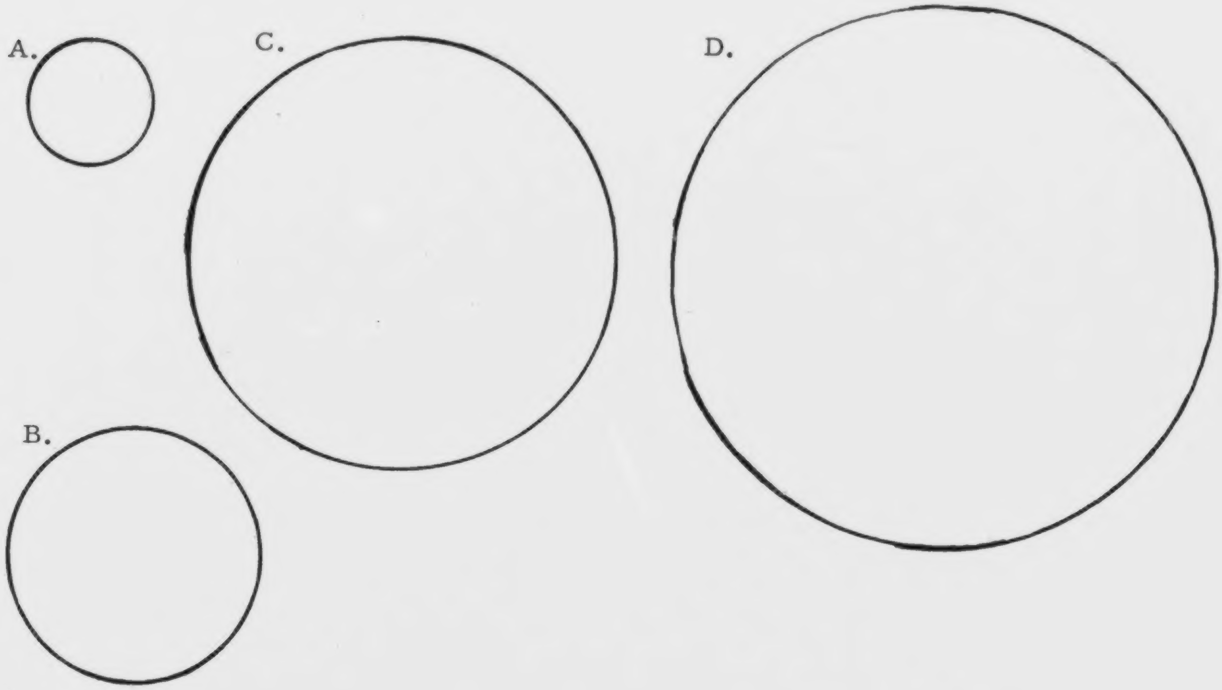
MATERIALS

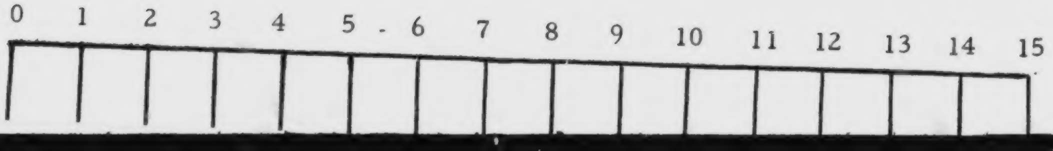
scissors

magnifying lens

PROCEDURE

1. Cut the measuring strip from the bottom of this page.
2. Use the measuring strip to find out how many times Circles B, C, and D have been magnified in relation to Circle A. Record your answers on the next page.

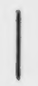




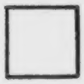
B	C	D

3. Using the magnifying lens as demonstrated by your teacher, observe the symbols below. In the space provided, sketch the symbols in the size they appear to you.

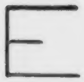
A.



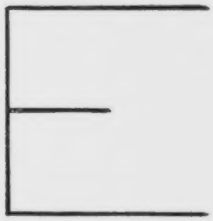
B.



C.



D.



4. Estimate the magnification of your sketches.

A. ________ C. ________

B. ________ D. ________

INTERPRETATION

1. What is the magnification of the lens you used?

2. Name other instruments that are used to magnify objects.

1A-6

INVESTIGATING ROCKS

You first tried to gain some knowledge of Planet G by observing photographs. Then you examined some samples of matter from the surface of Planet G directly. Now, you will take an even closer look at some of those samples, those that can be called rocks.

MATERIALS

rock samples
magnifier (magnifying lens)
bank pins

PROCEDURE

1. A magnifier gives you a closer look at rocks. Examine each rock with the aid of a magnifier. For each rock sample make a list of words that you think describes it accurately.

Rock #50	Rock #51	Rock #52	Rock #53	Rock #55	Rock #56

2\

2. When told to do so by your teacher, list the descriptive words for each sample on the chalkboard. Add to your own list any new words that other students put on the chalkboard.

INTERPRETATION

Select from the chart at least eight words that seem valuable in describing rocks. Enter them in the first column of the chart below. Explain your choices in the second column.

Term	Reason

1A-7

A CLOSER LOOK AT A ROCK

You have already examined several different kinds of rocks. Today you will examine a single kind of rock in greater detail.

MATERIALS

- rock sample
- magnifier
- paper towel
- crushed rock sample
- bank pin

PROCEDURE

1. You have been given one of the rock samples that you observed before. Look at it again and describe it briefly.

2. You have also been given a sample of the same rock that has been crushed. Place the crushed rock on the paper towel and separate it into piles of similar particles. How many piles do you get?

3. Look carefully at each pile. In the chart below list words that you think describe each kind of substance. You may not have as many different substances as there are columns in the chart.

Substance #1	Substance #2	Substance #3	Substance #4	Substance #5

INTERPRETATION

1. What are some differences between this list of descriptive words and those you listed in "Investigating Rocks"?

2. The substances that you have separated from the crushed rock are minerals. Which are easier to describe, rocks or minerals? Explain your answer.

3. What is the difference between a rock and a mineral?

1A-8

DETERMINING HARDNESS OF MINERALS

You have already learned that rocks are made of different minerals. One characteristic of minerals that helps you to identify them is hardness. In this activity you will learn how to find the hardness of minerals.

Part A

PROCEDURE

Read in the reference as directed by your teacher. Complete the following questions by circling the correct answer in the first four items and filling in the blanks in Item 5.

1. The hardness of a mineral refers to how it:

   a. breaks
   b. streaks
   c. scratches or becomes scratched by another mineral
   d. shows metallic luster

2. The hardness scale for minerals has a range of 1 to 10, arranged from:

   a. softest to hardest
   b. light streak to heavy streak
   c. glass to fingernail
   d. hardest to softest

3. The hardness of a mineral refers to its ability to scratch:

   a. other objects of standard hardness
   b. glass only
   c. a diamond
   d. other minerals only

4. The best way to tell whether a scratch was made on a mineral is to:

   a. look at the change in color
   b. rub on the mineral to see if a scratch is really on it
   c. rub on the mineral to see if any dust is present
   d. do both b and c

5. Locate a hardness chart in a reference book and find the hardness of each item below.

   a. your fingernail _____
   b. a copper penny _____
   c. a steel file _____
   d. glass _____
   e. quartz _____
   f. topaz _____
   g. diamond _____

Part B

MATERIALS

Hardness Kit #1

PROCEDURE

1. Use the materials in Hardness Kit #1 to determine the hardness of the mineral samples. Complete the chart by checking in the appropriate places.

Mineral #	Scratched by				
	Fingernail	Copper Penny	Nail	Glass	Steel File
5					
6					
8					
22					
23					

2. Using the information in the hardness chart in the reference and that in the chart above, assign a hardness number to each mineral sample.

Mineral	Hardness Number
5	______
6	______
8	______
22	______
23	______

1A-9

DETERMINING APPEARANCE OF MINERALS

You have learned how to determine the hardness of minerals. Today you will discover how to describe other characteristics of minerals that will be useful, later, in identifying them.

MATERIALS

mineral kit	Thurber and Kilburn. Exploring Earth Science
streak plate	Zim. Rocks and Minerals

PROCEDURE

1. Read Pages 212-214 in Exploring Earth Science and answer the questions below.

   a. Complete the following:

      1) Smooth is to cleavage as ____________ is to fracture.

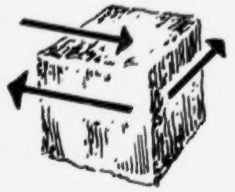
      2) Scratch is to streak as reflected light is to ______________.

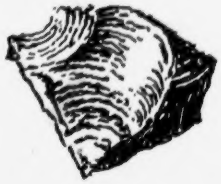
   b. The terms in the left hand column below are used to describe different kinds of luster. Select an example of each from the right-hand column and write its letter beside the appropriate term.

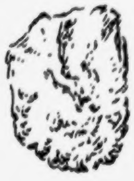
metallic	____________	a.	inside of an oyster shell
glassy	____________	b.	clay flower pot
pearly	____________	c.	watch crystal
dull	____________	d.	wedding ring

2. Study the illustrations and read the material on Page 20 of the Zim reference. Then complete the matching questions. The terms in the left-hand column are used to describe different kinds of fracture. From the right-hand column select the sketch that illustrates each kind of fracture and write its letter beside the appropriate term.

conchoidal _____
uneven _____

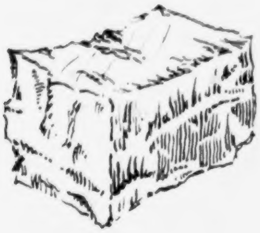

A.


B.

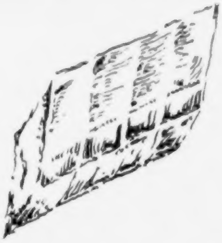

C.

3. Use both references to complete the matching question below. The terms below are used to describe cleavage - that is, how some minerals split. From the sketches below select one that illustrates each term and write its letter in the appropriate blank.

one side (direction) ______
two sides (direction) ______
three sides (direction) ______



A.



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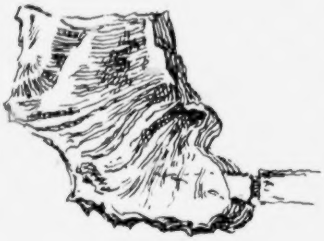


C.

INTERPRETATION

Complete the chart by describing the appearance of each mineral. Match the number on the specimen with the number on the chart.

	Color	Luster	Streak	Cleavage	Fracture
2					
3					
4					
5					
6					
7					
8					
9					
10					
13					
14					
17					
18					
19					
21					
22					
23					

COLLECTING ROCKS

You have learned how to identify minerals by means of their hardness and appearance. Now you will try to apply what you have learned to your own rock collection.

Part A

1. Name at least five instruments that extend the senses of the astronauts.

2. What can earth scientists learn by studying rocks from the moon and other planets?

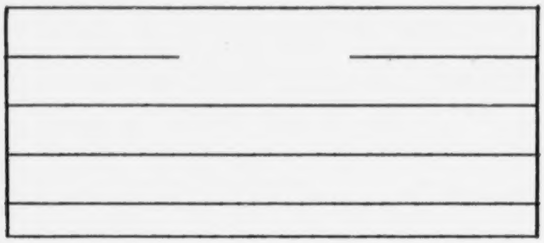
3. Read Pages 4-13 in Zim's Rocks and Minerals and answer the questions below.

    a. Describe 3 places where you may find rock specimens.

    b. List equipment you may need when collecting rocks.

1)	4)
2)	5)
3)	6)

4. Complete the blank on the chart below to indicate one useful way to label specimens.



Part B

MATERIALS

- hardness test materials
- streak plate
- rock specimens, 6
- small containers of crushed rock, 6
- egg carton
- bank pin
- paper towels
- magnifier

PROCEDURE

1. Do the following as a home assignment:

   Select 6 different specimens from your rock collection. Crush enough of each rock so that you have about the same amount as you used in Investigation #7, "A Closer Look at a Rock." Bring to class 6 hand specimens (about 1 inch square) and the 6 samples of crushed rock. Number both the rocks and the crushed material from 1 to 6.

2. Use the 6 catalog sheets provided on the following pages to record information concerning the rock specimens. It is not necessary to identify rocks.

No. ___1___ Date ____________

Name of rock ________________

Locality ____________________

____

Collector ___________________

Number of different minerals
in Rock #1 ______________

Characteristics

Color	Luster	Streak	Fracture and Cleavage	Hardness

No. ___2___ Date ____________

Name of rock ________________

Locality ____________________

____

Collector ___________________

Number of different minerals in
Rock #2 ______________

Characteristics

Color	Luster	Streak	Fracture and Cleavage	Hardness

No. 3 Date ____________

Name of rock ____________

Locality ____________

____

Collector ____________

Number of different minerals in Rock #3 ________

Characteristics

Color	Luster	Streak	Fracture and Cleavage	Hardness

No. 4 Date ____________

Name of rock ____________

Locality ____________

____

Collector ____________

Number of different minerals in Rock #4 ________

Characteristics

Color	Luster	Streak	Fracture and Cleavage	Hardness

No. 5 Date ________

Name of rock ________

Locality ________

____

Collector ________

Number of different
minerals in Rock #5 ________

Characteristics

Color	Luster	Streak	Fracture and Cleavage	Hardness

No. 6 Date ________

Name of rock ________

Locality ________

____

Collector ________

Number of different
minerals in Rock #6 ________

Characteristics

Color	Luster	Streak	Fracture and Cleavage	Hardness

1A-11

DISCOVERING ANOTHER CHARACTERISTIC

It is possible to identify a mineral if enough of its characteristics are known. You have observed the appearance and hardness of minerals. In this investigation you will discover another characteristic important in observing rocks and minerals

PROCEDURE

Suppose that five mineral samples were tested with the results given in the table below. Study the table and answer the questions on the next page.

Mineral Sample	Color	Streak	Hardness	Specific Gravity	Cleavage	Fracture	Luster
A	White	White	2.5	2.7	3 sides	Conchoidal	Glassy
B	Black	Black	2	2.3		Uneven	Metallic
C	White	White	2.5	2.1	3 sides	Conchoidal	Glassy
D	White	White	2	2.3	2 sides	Conchoidal	Pearly
E	Black	White	5	3.4	2 sides	Even	Glassy

INTERPRETATION

1. Complete the following statements by choosing the distinguishing characteristic or characteristics.

   A. Sample A can be distinguished from Sample E by

   B. Sample B can be distinguished from Sample D by

   C. Sample C can be distinguished from Sample D by

   D. Sample A can be distinguished from Sample C by

2. If you were given the job of actually testing the above minerals which tests could you presently perform?

3. Which characteristic are you unable to test until you know more about it?

1A-12

A PRINCIPLE OF MEASUREMENT

Most of your observations have been the kind that describe general qualities or characteristics of objects. These are called qualitative observations. However, many observations require you to measure objects so that you can record a quantity or amount. These are called quantitative observations. In this investigation you will learn to measure length accurately.

PROCEDURE

1. Use only the materials provided by the teacher in making the measurements. Record your results on the chart below.

2. Record the measurements obtained by any four other students.

Student	Paper Length	Desk Length	Desk Width	Chalkboard Length
My Results				
Student 1				
Student 2				
Student 3				
Student 4				

INTERPRETATION

1. Do all students report the same measurement for each object?

2. Look at the desk tops in the room. Are they all approximately the same length? Do the measurements on your chart indicate this?

3. Is it necessary to use the same unit when comparing measurements? Explain your answer.

4. If students are to compare results, what characteristic must the instruments they use have in common?

MEASURING LENGTH

Part A

You have found that standard units are necessary in order to communicate measurements accurately. In this investigation you will use three standard units for measuring length. Measures of length are called "linear measures" and the units used are called "linear units."

MATERIALS

white units	blue unit
orange units	blank sheet of paper, 8 1/2" x 11"

PROCEDURE

1. Use the units provided to measure the following distances:
   - a. length of the sheet of paper
   - b. length of your desk
   - c. width of your desk
   - d. length of the chalkboard

   Record the measurements in the chart.

Things to Be Measured	White Units	Orange Units	Blue Units
Length of the Sheet of Paper			
Length of Your Desk			
Width of Your Desk			
Length of the Chalkboard			

2. Share your results with four other students and record their results for the length of the paper and the length of the chalkboard.

Things to Be Measured	Student	White Units	Orange Units	Blue Units
Length of Paper	1			
	2			
	3			
	4			
Length of Chalkboard	1			
	2			
	3			
	4			

3. How many white units does it take to make one orange unit?

_________ white units = ___1___ orange unit

4. How many orange units does it take to make one blue unit?

____________ orange units = ___1___ blue unit

INTERPRETATION

1. Did the measurements that the class made of the lengths of the paper and the chalkboard agree better than they did in the previous activity? Explain.

2. Compare your measurement of the length of the paper with measurements made by the four other students. Are the measurements all approximately the same?

3. Was it easier to compare measurements using the agreed-upon standards of this investigation than it was to compare measurements in the activity before? Explain.

4. From your answers to Items 3 and 4, calculate how many white units are in one blue unit.

5. How would it be possible to include all three of these units in one measuring device or instrument?

6. Would it be useful to have a unit smaller than the white one? If so, how many of these smaller units would you use to make a white unit?

Part B

In Part A of this investigation you used three separate standard units for measuring lengths. You found, however, that these separate units were related to one another. In Part B you will be given a measuring device that contains all of those units plus the fourth unit suggested in Interpretation Item 6. At the conclusion of Part B, you should be able to measure length in the metric system.

MATERIALS

white unit	blue unit
orange unit	standard length-measuring device

PROCEDURE

1. Use the standard length-measuring device with the three units used in Part A.

______________ blue units = 1 standard length

______________ orange units = 1 standard length

______________ white units = 1 standard length

2. The length of the length-measuring device is a unit called the meter (m). One tenth of a meter is equal in length to one orange unit. This distance is called a decimeter (dm). One hundredth of a meter (one white unit) is called a centimeter (cm). If you look carefully at the marks on the device (called a meter stick) you find that the centimeter is also divided into ten equal parts. One of these parts is known as a millimeter (mm). These units are parts of the metric system of measurement.

3. Complete the following

1 centimeter = _____ millimeters

1 meter = _____ decimeters

1 decimeter = _____ centimeters

1 meter = _____ centimeters

1 decimeter = _____ millimeters

1 meter = _____ millimeters

4. Measure the distance between each of the points shown on the next page. Record your results below, using the units of the metric system that are given.

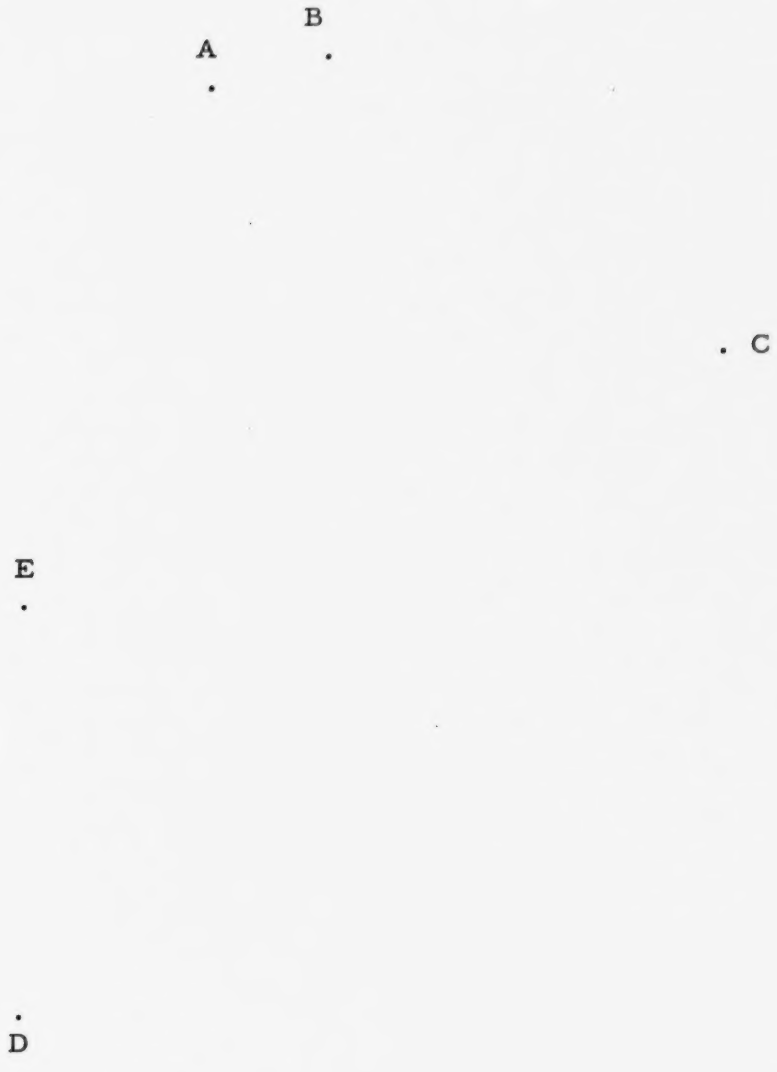
A to B = _______ mm

D to C = _______ mm

A to C = _______ cm

D to C = ______ cm

B to E = _______ cm


B
A
C
E
D

5. Measure and record in the metric system the height of your desk.

6. Measure and record in the metric system the height of another student.

INTERPRETATION

1. Give an example of a situation in which a millimeter is too small to use in making a linear measurement conveniently.

2. Give an example of a situation in which the meter is too large to use in making a linear measurement conveniently.

3. If a unit of measurement larger than the meter is desired how many times larger than a meter should this be?

4. If a unit of measurement smaller than the millimeter is desired how many such units should it take to make a millimeter?

5. In order to complete a plumbing system it was found that a pipe 230 centimeters long was needed. Would a pipe with a length of 2370 millimeters fit the space? How much would have to be added or taken away from the original pipe length of 2370 millimeters to fit the space?

1A-14

SIZES OF SURFACES

Now that you can make measurements of distances with the metric system, it will be helpful to learn how to measure the sizes of the surfaces of some flat objects. For example, you could measure the length and the width of the classroom, but these measurements would not give you a measure of the flat surface formed by the floor. In this investigation you will be measuring flat surfaces in two ways.

MATERIALS

white area units
sample surfaces to be measured
ruler graduated in centimeters

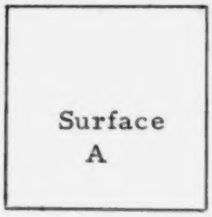
PROCEDURE

1. How many white units are needed to cover Surface A?

2. Measure the length and width of Surface A, using the edge of one of the white units as the linear unit.

3. Multiply the number of units in the length times the number of units in the width for Surface A.

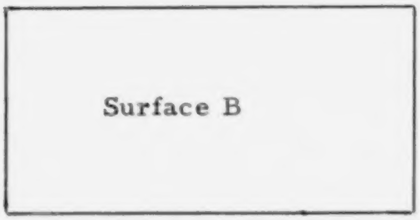
4. Repeat Steps 1 through 3 for Surfaces B and C.



a. White units = ______

b. Length= _______
Width = _______

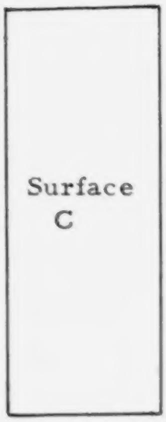
c. Length x Width =______



a. White units= _____

b. Length=__________
Width=__________

c. Length x Width=_____



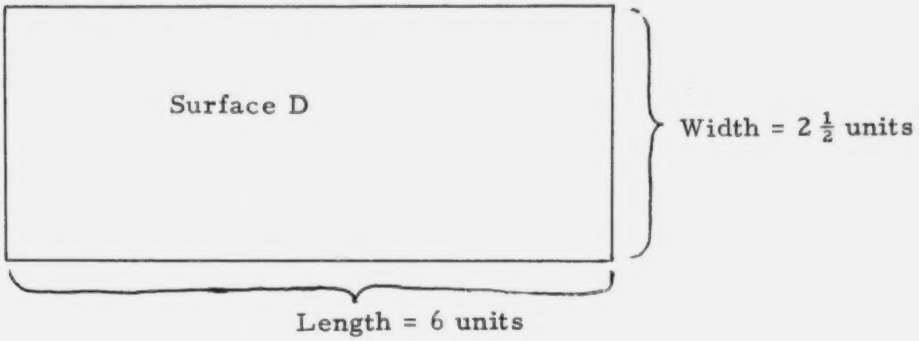
a. White units=_____

b. Length=______
Width=_______

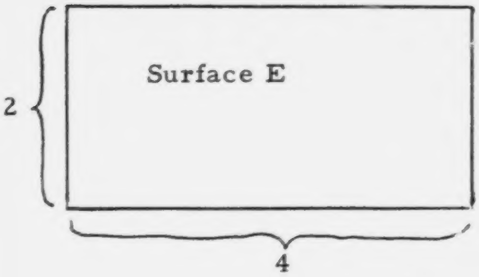
c. Length x
Width=_______

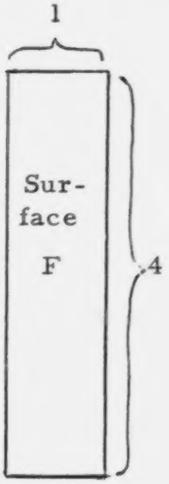
5. In each of the surface measurements, how did the number of white units that fit on the surface compare to the product of length x width?

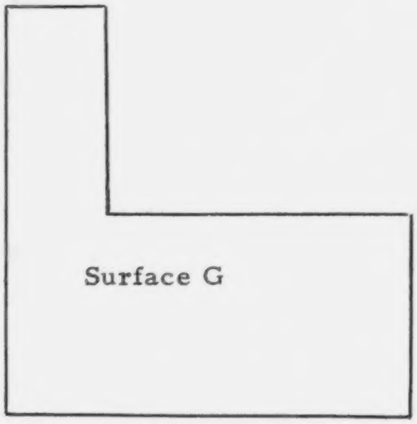
6. In Surface D the measurements of length and width are given. Find the number of white units that will fit on the surface without using your white units. You may check your answer by using your white units.


Surface D
Width = 2 ½ units
Length = 6 units

7. In the Surfaces E and F, the measurements are given. Find the number of white units that would fit on each surface. Use the measurements or your white units.


Surface E
2
4


1
Surface F
4



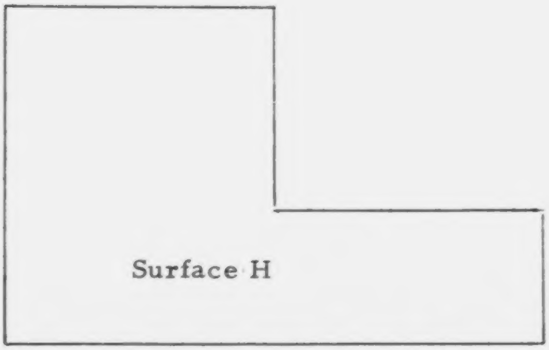
8. Surface G was made by overlapping F on E. Find the number of white units that would fit on the surface.

9. Because of its shape, another name you could use for the white unit would be "square unit." If you made another white unit that measured exactly one centimeter on each side, what could you name it?

10. Measure the length and width of Surfaces E and F in centimeters. How many units that measure one centimeter on each side would fit on each surface?

11. How many units that measure one centimeter on each side would fit on Surface G?

12. How many units that measure one centimeter on each side would fit on Surface H?



INTERPRETATION

1. If the area of a surface is defined as the number of square units that fit on a surface, what two ways did you use to find area in the investigation?

2. A unit of area in the metric system is the square centimeter (cm^2). List its characteristics as to shape and linear dimensions.

1A-15

MEASURING THE SPACE THAT MATTER OCCUPIES

One way to measure surfaces is to select a convenient unit of area and count how many times it fits on the surface to be measured. Similarly, you can measure volume by fitting solid cubes into every portion of a space.

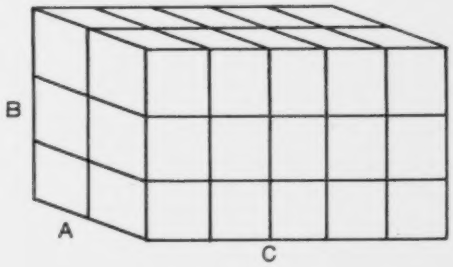
Part A

MATERIALS

30 cubes

PROCEDURE

1. Using the cubes, construct a rectangular solid like the one below. Call this Solid #1. Count the number of cubes you used to construct the solid and record in the chart on the next page. Then count the number of cubes along each of the edges of the rectangular solid and record these counts in the chart.



2. Using a different number of cubes, construct a second rectangular solid. Call this Solid #2. On the second line of the chart record the required information. Then use a still different number to construct a third rectangular solid, Solid #3, and complete the chart.

3. Multiply the numbers of cubes counted along each of the edges to get a product for each solid and record your answers in the last column of the chart. For example, if Edge A is 2 cubes, Edge B is 3 cubes, and Edge C is 4 cubes, then 2 x 3 x 4 = 24.

	Total Number of Cubes Used to Construct Rectangular Solids	Number of Cubes Used			A X B X C
		Edge A	Edge B	Edge C	
Solid 1					
Solid 2					
Solid 3					

INTERPRETATION

1. How does the product of the number of cubes on each side compare with the number of cubes you used to construct the solid?

2. If you know the linear measurements of the length, width, and height of a rectangular solid, how can you find the volume of that solid?

Part B

MATERIALS

metric ruler or meter stick
rectangular solids, 6 samples

PROCEDURE

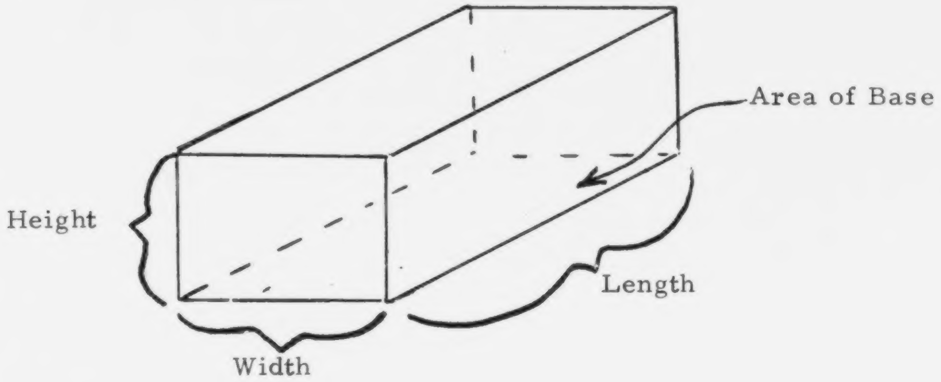
Measure the length, width, and height of the six numbered rectangular solids. Record your measurements in centimeters in the chart below. Let the longest measured side of the rectangular solid be called the length.

Samples	Length	Width	Height	Volume= LxWxH
#1				
#2				
#3				
#4				
#5				
#6				

INTERPRETATION

1. Compare your measurements of the volumes of the rectangular solids with those of another student. Are your values for the volumes of these solids the same as those of the student with whom you compared? If not, how can you account for any differences?

2. Another way to find the volume of a rectangular solid is to multiply the area of the base by the height. Assume each rectangular solid is in a position like the drawing below, with the length and width as measures of the base surface.



a. What is the area of the base for Sample G?

b. Multiply the area of the base by the height in Sample G. Is this volume equal to the volume you recorded in the chart?

c. Find the volume of the other samples by multiplying the area of the base by the height. Do these volumes agree with those in the chart?

1A-16

A VOLUME-MEASURING DEVICE

The procedure for finding the volume of irregularly-shaped objects is not as simple as that for finding the volume of a rectangular solid. You have seen that certain solids, when placed in water, cause the water level to rise. The amount that the water level rises depends on the volume of the solid. In this activity you will use this property of solids to construct a volume-measuring device.

Part A

MATERIALS

clear plastic tube,
  closed at one end
glass marbles, 4
transparent tape
metric ruler
water in beaker

PROCEDURE

1. Put the water into the plastic tube until it is half-filled. Mark the level of the water on the strip of tape on the tube.

2. Tilt the tube and carefully roll one marble into the water. With the tube upright, mark the new water level in the tube.

3. Leaving the first marble in the water, carefully add a second marble. Again mark the new water level in the tube.

4. Continue the marble-adding procedure until 4 marbles are in the tube and each new water level is marked.

5. With your metric ruler measure the distance from the original water level to each of the levels obtained by adding marbles. Record the data in the chart below.

Number of Marbles in Tube	Height of Water In Millimeters
0	
1	
2	
3	
4	

INTERPRETATION

1. How did the rise of water caused by the first marble compare with the rise caused by each additional marble?

2. How do the volumes of the marbles compare with each other?

3. Predict how far the water level would rise if a fifth marble were added to the plastic tube.

4. Could a tube such as this be used for measuring the volume of irregularly shaped objects? Explain.

5. How could you go about continuing the markings on your tube?

Part B

MATERIALS

tape, graduated
glass marbles, 2 cm^3, 2
clear plastic tube, closed at one end

PROCEDURE

Using the materials that you have been given, produce a volume-measuring device that will measure cubic centimeters (cm^3).

INTERPRETATION

1. What is the volume in cubic centimeters measured by each division on the tape?

2. If this is to be a useful volume-measuring device, why is it important that the bottom line should match up with the bottom of the inside of the tube?

3. Would it be possible to use this device to measure the volume of liquids? If so, how?

Part C

MATERIALS

graduated cylinder, 100 ml
metric ruler
rectangular solids, 2
water

PROCEDURE

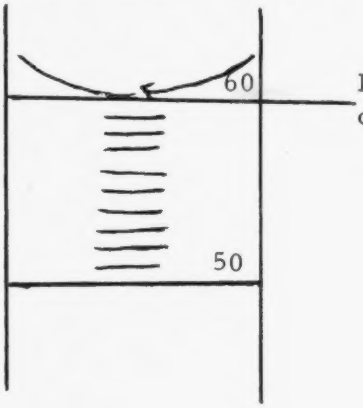
1. Measure the edges of each of the two rectangular solids in centimeters. Use these dimensions for computing the volume of each rectangular solid. Record your results below.

_______ X _______ X _______ = _______

_______ X _______ X _______ = _______

2. The instrument you are going to use now is similar to the volume-measuring device in Parts A and B. This manufactured instrument is called a graduated cylinder. The abbreviation ml is located on the side of the graduated cylinder. It represents another metric unit, the milliliter. The space between two lines in your graduated cylinder will hold one milliliter of volume. What is the largest volume you can measure with this graduated cylinder?

3. When water is poured into a graduated cylinder it curves at the surface. This curve is called the meniscus. When measuring with a graduated cylinder, read the lowest level of the curve.



Read water level at end of arrow.

4. Pour water into the graduated cylinder until the meniscus is at the line marked 60. Holding your graduated cylinder on a slant, carefully slide the smaller rectangular solid into it. Record the rise of the water level by counting the lines on the graduated cylinder from the original water level. The water rose ____________ lines or ______________ milliliters.

5. Repeat Procedure 4, but use the larger rectangular solid. The water rose _____________ lines or ______________ milliliters.

INTERPRETATION

1. How did the number of cubic centimeters of volume for each rectangular solid compare with the number of milliliters the water rose in the graduated cylinder?

2. If you placed a rectangular solid with a measured volume of 35 cubic centimeters in a graduated cylinder containing water, how many milliliters would the water level rise?

1A-17

MEASURING MASS

If you hold a large piece of rock in one hand and a small piece of the same rock in the other hand you can easily tell by the "feel" which is the large piece. However, if the two samples are almost the same size it is very difficult to detect any difference simply by holding them in your hand. In this instance you would need to use an instrument to compare the objects to a standard mass. In this investigation you will construct your own mass-measuring device.

Part A

MATERIALS

- meter stick
- spool of thread
- knife edge
- knife edge support
- samples from surface of Planet G
- metal washers
- wire
- rubber stoppers, 1-hole

INVESTIGATION

1. Select a partner and discuss with him possible ways to make a mass-measuring device from the materials you have been supplied. Design and construct the instrument.

2. Diagram the instrument and describe how it works.

3. Determine the mass of the samples from Planet G by using your newly constructed instrument. Record the masses in the chart below.

Sample	My Team's Results	Other Team's Results
1		
2		

4. Exchange samples with a nearby team and determine their masses. Record the results of the other team in the chart.

INTERPRETATION

1. Compare your results with those of the other team. Account for any differences.

2. Would it be helpful if all of the instruments in the class were identical? Explain.

Part B

MATERIALS

meter stick
knife edge
wire hook slides
bundles of metal washers (5, 4, 3)
single washer with wire loop
knife edge support

PROCEDURE

1. Set the knife edge indicator on the 50 cm mark of the meter stick and place it on the support. If the meter stick will not remain horizontal, adjust the position of the knife edge until it does so. Record the position of the knife edge indicator in the section of the chart marked pivot point. Put wire hook slides on the meter stick, one on the left and one on the right of the pivot point. Place the left-hand wire hook on the 40 cm mark. Do not move it. Record the distance from the 40 cm mark to the pivot point in the chart under the section of the chart marked Left-hand Distance. Since the left-hand hook will not be moved, this distance remains unchanged during the entire investigation. Attach the bundle of 5 washers to the left-hand wire hook and the single washer to the right-hand wire hook. Move the right-hand hook with its washer until the bundle of 5 washers is balanced. Record the distance of the right-hand hook from the pivot point in the section of the chart marked Right-hand Distance. Repeat the procedure using first the bundle of 4 washers on the left-hand hook and then the bundle of 3 washers.

2. Find the product of the number of washers in the bundle times the left-hand distance and put the numbers in Column III.

3. Find the product of the number of washers on the right (1) times the right-hand distance and put the numbers in Column IV.

PIVOT POINT ________

I	II	III	IV	V
Number of Washers in Bundle	Left-hand Distance	Number of Washers on Left X Left-hand Distance	Number of Washers on Right X Right-hand Distance	Right-hand Distance
5		5 x ( ) =	1 x ( ) =	
4		4 x ( ) =	1 x ( ) =	
3		3 x ( ) =	1 x ( ) =	

INTERPRETATION

1. Compare the product numbers in Columns III and IV. Are the product numbers nearly the same or is there a big difference between them?

2. If you put 6 washers on the left, in which direction would you have to move the slide on the right to balance the six washers? Explain.

3. If you put 2 washers on the left, in which direction would you have to move the slide on the right to balance the two washers? Explain.

4. If you put one washer on the left, how far from the pivot point would you place the slide in order to balance the right-hand washer?

1A-18

A MASS-MEASURING DEVICE

Investigation 1A-17 gave you some experience with an unequal-arm balance. In this investigation you will use another unequal-arm balance, a type commonly used in laboratories.

MATERIALS

triple beam balance
filter paper
marble sample
granite sample

density kit
beaker, 400 ml
water

PROCEDURE

1. Slide the masses on the front beam, center beam, and back beam to the zero marks on the triple beam balance.

2. Turn the adjustment screw in or out until the pointer is in line with the zero mark on the right of the balance. When you have done this, your balance is ready for measuring the mass of an object.

3. Measure the mass of the objects listed in the chart below. Record your measurements in the first blank column of the chart. Now have your partner measure the mass of the objects independently. Place his measurements in the second blank column of the chart.

Object	Mass of Object Measured in Grams	
	Yours	Your Partner's
1. filter paper		
2. aluminum cube		
3. aluminum bar		
4. 400 ml beaker		
5. 400 ml beaker half-full of water		
6. marble sample		
7. granite sample		

INTERPRETATION

1. Why is it necessary for all weights to be on zero and the pointer in line with the zero mark on the balance before measuring the mass of an object?

2. How did your measurements of Objects 1 through 7 compare with those made by your partner? How can you account for this?

1A-19

PUTTING MEASURING SKILLS TO WORK

In the last seven activities you have learned a number of measurement skills. In this investigation you will have the opportunity to use these measurement skills in describing objects from Planet G.

MATERIALS

graduated cylinder, 50 ml
triple beam balance
metric ruler
samples from Planet G, 3
thread

PROCEDURE

1. You are given three samples from Planet G. Using any of the materials supplied, make measurements of the samples. You should make enough measurements of each sample so that another student, using only your results and his own measurements, will be able to identify any one of your samples.

2. In the chart below place in each of the top blocks the kind of measurement you are going to use. Below each, place the actual measurement of the sample. You may extend the chart to include as many kinds of measurements as you desire.

Measurements of Samples

Sample					Kind of Measurement
A					
B					
C					

DESCRIBING MINERALS

MATERIALS

mineral samples, 7
triple beam balance
metric scale
copper penny
iron nail
glass slide
graduated cylinder, 250 ml, half-filled with water
streak plate

PROCEDURE

You have been provided with a set of minerals. Describe them by filling in as many spaces as you can on the chart below.

Sample Number	Mass	Volume	Streak	Hardness	Cleavage	Fracture	Luster or Color	Crystal
3								
5								
9								
17								
19								
22								
28								

INTERPRETATION

1. Which samples were most easily described by the following characteristics?

Characteristic	Sample Numbers
Mass	
Volume	
Streak	
Hardness	
Cleavage	
Fracture	
Crystal Shape	
Other	

2. Which of the above characteristics were most useful in describing the samples?

3. Which of the characteristics were least useful in describing the samples?

1A-21

OTHER TESTS FOR MINERALS

You have just observed several demonstrations useful in finding out about some special characteristics of certain minerals. Now read Pages 22-24 and 29 in Zim's Rocks and Minerals and answer the questions below.

1. Place a check beside the word or phrase that best completes each statement.

   a. Radioactivity is detected by:

      a flame test
      ultra-violet rays
      magnetic properties
      a geiger counter

   b. Phosphoresence is detected by:

      a flame test
      ultra-violet rays
      magnetic properties
      a geiger counter
      none of the above

   c. Copper, when heated in an open flame, colors the flame:

      yellow
      red
      blue
      violet
      all of the above

2. Suppose that a large box of rocks is brought into the classroom when a geiger counter is turned on, the ultra-violet lamp is burning, and a large magnetic compass is on the demonstration table. How would you go about grouping the rocks? List the names of your groups.

1A-22

THE RELATIONSHIP BETWEEN MASS AND VOLUME: PART I

When you were measuring the mass and volume of objects you may have wondered how this information would be useful in identifying the minerals and rocks you have been studying. In the next series of investigations you will discover how these measurements can be used to determine a characteristic that will be helpful in mineral identification.

MATERIALS

graduated cylinder, 100 ml
beaker of water
triple beam balance

PROCEDURE

1. Use the balance to determine the mass of the empty graduated cylinder. Record this mass here.

2. Pour water into the graduated cylinder to the 10 ml mark. Measure the mass of the water and record in the chart below. Repeat the above procedure for 20, 30, 40, and 50 ml of water.

Volume of Water in Milliliters	Mass of Water in Grams
10	
20	
30	
40	
50	

INTERPRETATION

1. How did the mass of the water change as you increased its volume?

2. Judging from the data on your chart what do you think would be the mass of 1 ml of water? ____________ g

3. Judging from the data on your chart what do you think would be the mass of 100 ml of water? _________ g

4. The chart you prepared shows ordered pairs of measurements. The volumes (10, 20, 30, 40, 50 ml) were listed in order from lowest to highest and the mass of each placed next to it.

   Measurements of characteristics of matter can be called variables. A variable is a measurement that can vary or change in its value. A measurement that does not depend on another measurement for its value is called an independent variable. Often the independent variable is the set of measurements that has already been ordered or listed in a data chart.

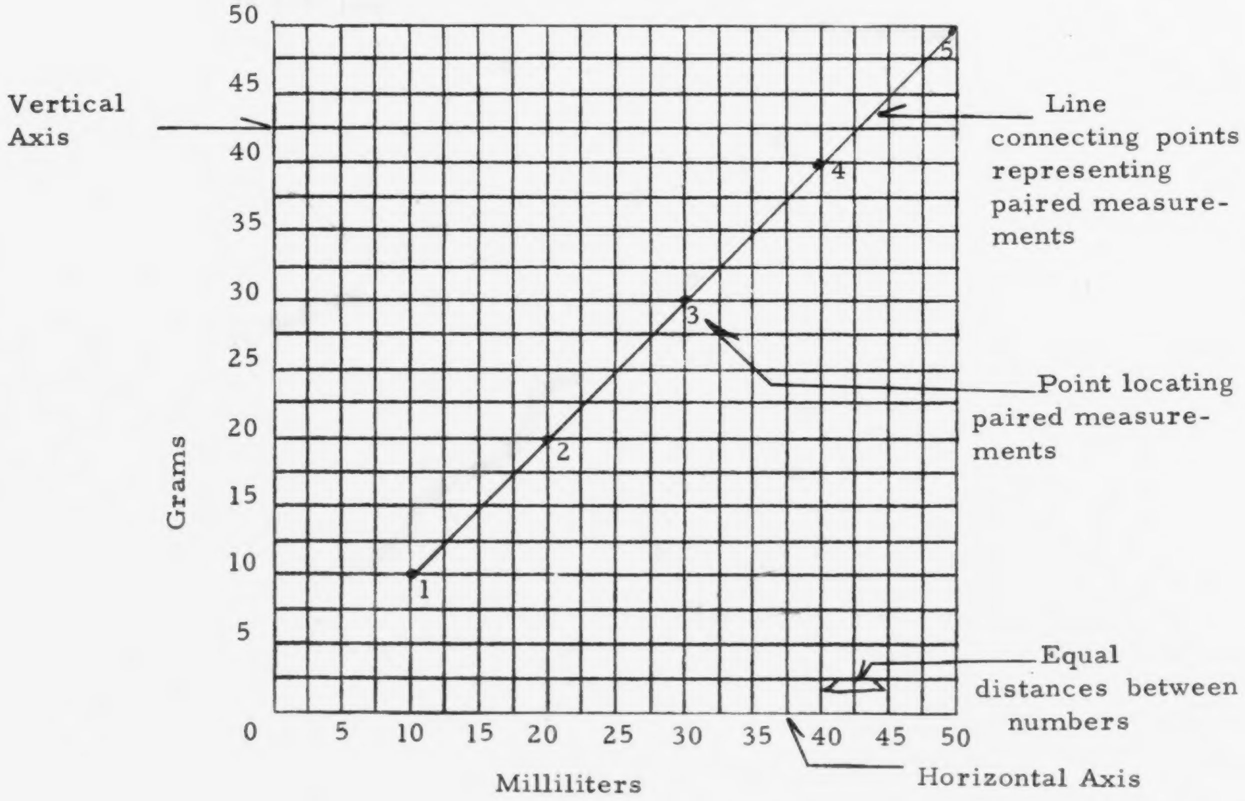
   a. In your data chart does each volume depend upon a mass or does each mass depend upon a volume? Explain your answer.

   b. Which set of the variables in your chart (mass or volume) is the independent variable?

   c. A dependent variable is a measurement that depends upon another measurement. Which of the variables in your chart (mass or volume) is the dependent variable?

5. A line graph is one way of illustrating the relationship between ordered pairs of measurements. The following line graph might represent the data obtained in this investigation.

MASS VERSUS VOLUME FOR TAP WATER



a. Which axis (vertical or horizontal) shows mass measurements?

b. Which axis shows volume measurements?

c. On which axis do you find the measurements that were already ordered in the data chart?

d. On which axis is the independent variable?

e. On which axis is the dependent variable?

f. What does Point #1 on the line graph tell you about the mass and volume of water?

g. What does Point #4 on the line graph tell you about the mass and volume of water?

h. According to the graph line what is the mass of 25 ml of water?

i. What is the volume of 35 grams of water?

1A-23

THE RELATIONSHIP BETWEEN MASS AND VOLUME: PART II

When you measured the volume of a sample of water with a graduated cylinder, you found that one milliliter of the water had approximately a mass of one gram. In other words, the mass-to-volume ratio for water is approximately one. Now you will investigate the mass-to-volume ratio of other liquids. One of the three liquid samples is pure water. Can you find out which sample is water? Do not taste the solutions.

MATERIALS

triple beam balance	beakers, 150 ml, 3
liquids, 3 samples, 100 ml each	graduated cylinder, 100 ml

PROCEDURE

1. Determine the mass of the empty graduated cylinder. Record this mass. __________ g

2. Pour water into the graduated cylinder to the 10 ml mark. Determine the mass of Liquid #1 and record in the chart below.

3. Repeat the procedure for volumes of 20, 30, 40, and 50 milliliters.

Volume of Liquid #1 in Milliliters	Mass of Liquid #1 in Grams	$\frac{M}{V}$
10		
20		
30		
40		
50		

4. Repeat the procedure, using Liquids #2 and #3. Place the measurements in the charts below.

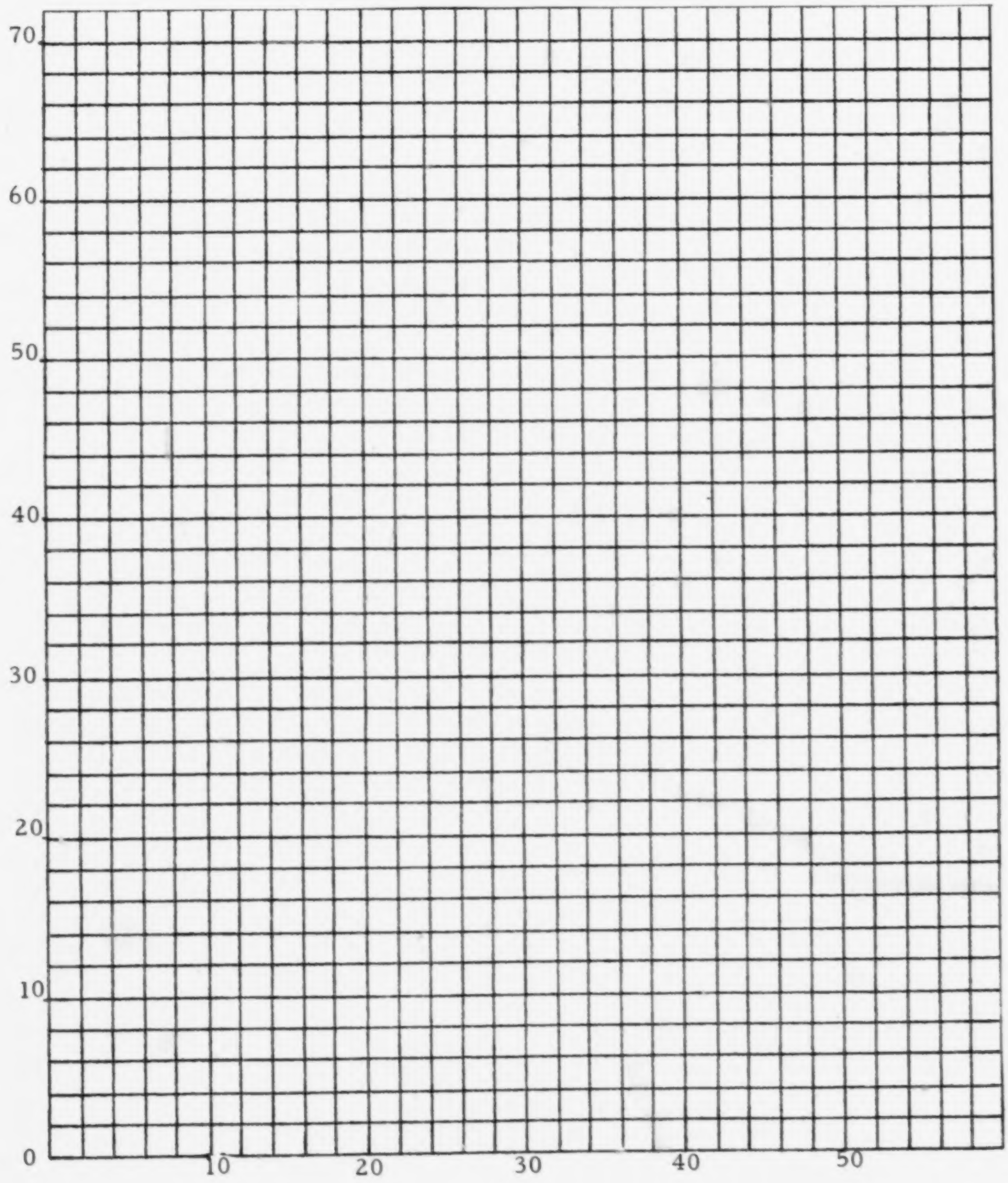
Volume of Liquid #2 in Milliliters	Mass of Liquid #2 in Grams	$\frac{M}{V}$
10		
20		
30		
40		
50		

Volume of Liquid #3 in Milliliters	Mass of Liquid #3 in Grams	$\frac{M}{V}$
10		
20		
30		
40		
50		

5. After you have determined the masses for each liquid, divide the mass of each liquid by its volume for 10, 20, 30, 40, and 50 ml. Express your answer, the quotient, to the nearest one tenth (.1). Enter the quotients in the $\frac{M}{V}$ columns of the data charts.

6. On the grid below plot the points representing the ordered pairs of data from the three charts. Connect the plotted points using some kind of code (color, dotted line, broken line, etc.) to distinguish the data obtained from each liquid sample. Provide each axis with an appropriate label.

MASS VERSUS VOLUME FOR THREE LIQUIDS



INTERPRETATION

1. Name the independent variable. On which axis did you plot the independent variable?

2. Which of the three liquids had more mass than its volume? ________
   Which of the three liquids has less mass than its volume? ________
   Which of the three liquids had about the same mass as its volume? ________
   What evidence in the graph supports your answers above?

3. Which of the three liquids is water? On what evidence do you base your answer?

4. In Item 5 of the procedure, you divided the mass of each liquid by its volume. Fill in the blanks with the quotient that best represents each liquid.

   Liquid #1 $\frac{M}{V}$ = ________

   Liquid #2 $\frac{M}{V}$ = ________

   Liquid #3 $\frac{M}{V}$ = ________

   The units should show what measurement has been divided by what other measurement. Write the label or units beside each calculation above.

5. How might you use the relationship between mass and volume of an object in helping to identify rocks and minerals?

DETERMINING THE DENSITY OF SOLIDS

You have already learned how to determine the volume of solid objects by the displacement method. In this investigation you will use this procedure to find the density of solid objects.

MATERIALS

aluminum cube
aluminum slab
steel ball
rock samples, 2
dissecting needle
graduated cylinder, 100 ml
balance
beaker of water, 50 ml
metric scale

PROCEDURE

1. Pour water into the graduated cylinder to the 50 ml mark. Record the exact level of the water.

2. Find the volume of the cube by measuring with a metric scale and calculating. Record to the nearest tenth of a cubic centimeter.

3. Find the volume of the aluminum cube in ml by placing it in the water in the graduated cylinder. Be careful to hold the cylinder in such a way that the cube slides gently into the water without splashing. Record the volume.

4. Compare the volume found by Procedure 3 with that found by Procedure 2. Are they alike or different?

5. Find the mass of the aluminum cube.

6. Repeat the above procedures using the aluminum slab, the steel ball, and the two rock samples. If one of the rock samples gives you trouble at one step of the procedure, perhaps you can use the dissecting needle to solve your problem. Record measurements of volume and mass for each of the samples in the chart below. Calculate the density of each object.

Object	Volume in Cubic Centimeters	Volume in Milliliters	Mass in Grams	Density $(\frac{M}{V})$
Aluminum Cube				
Aluminum Slab				
Steel Ball				
Rock #22				
Rock #57				

INTERPRETATION

1. Were all of the methods you used for determining density successful? If not, what difficulties did you encounter?

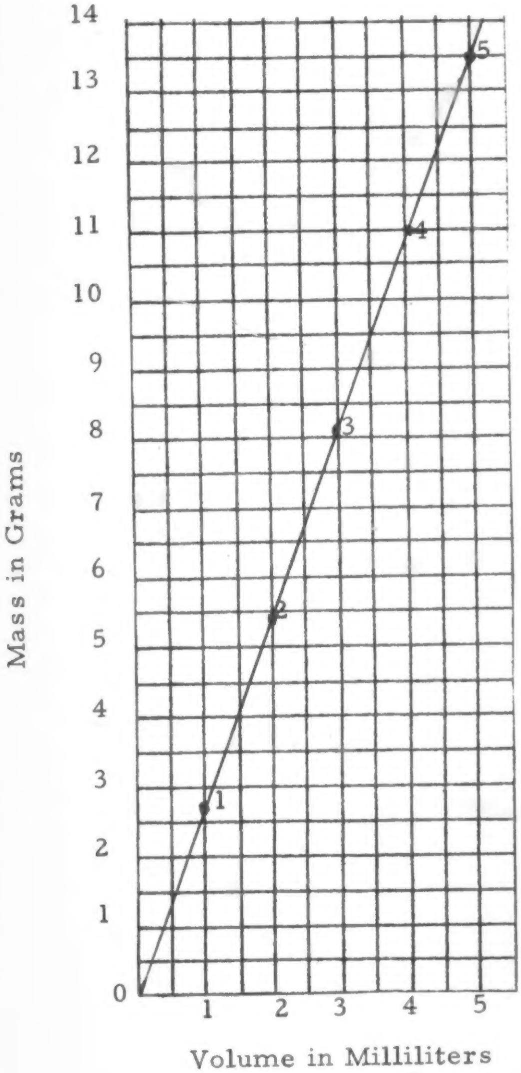
2. How did you use the dissecting needle?

3. What are some sources of error in this investigation?

4. Why were you unable to find the volume of the steel ball and rock samples in cubic centimeters?

5. After comparing the volume of the aluminum samples in centimeters and milliliters, what can you predict about the volume of the sphere and the rocks in cubic centimeters?

6. Below is a graph of mass versus volume of a solid material.



Which measure is the dependent variable?

7. Which point on the graph says, "Three cubic centimeters of this material has a mass of 8.1 g"?

8. What are the mass and volume at Point #5? What is the density at this point?

9. Is the density for all other points on the graph the same as the density in Question 7 and 8 above?

10. In the investigation you determined the density of several objects. Which objects had the same density as that illustrated by the graph?

1A-25

THE DENSITY OF AIR

You have found the densities of some liquids and solids. Today you will see a demonstration of one method for determining the density of a gaseous material. Your teacher will probably use air for the demonstration. Keep in mind that air is a mixture of several substances.

PROCEDURE

Observe the steps followed by your teacher. They are similar to the procedures you followed in the previous investigations, except for the use of a few pieces of specialized apparatus.

Your teacher will give you suggestions for recording the data from the demonstration.

INTERPRETATION

1. Describe the method your teacher used to find the volume of the container of air.

2. What was the density of air in this demonstration? How does the density of air differ from the densities of all the objects in previous investigations?

3. Is the density of air greater than or less than that of water? How is this related to the observation that air-filled objects, such as surf mats, float on water?

SPECIFIC GRAVITY

In addition to the characteristics you have already studied, geologists often use a quantity called specific gravity to help in identifying minerals. Specific gravity is the comparison between the weight of an object and the mass of an equal volume of water. Today you are going to find the specific gravity of some mineral samples.

MATERIALS

mineral samples, 6
spring scale, 500 g, or triple beam balance
beaker, graduated, 250 ml

PROCEDURE

1. Using the techniques demonstrated by your teacher, determine the weight of each sample in air and again submerged in water. Record the data in the appropriate spaces in the chart below.

Sample	Weight in Air (grams)	Weight in Water (grams)	Loss of Weight (grams)	Specific Gravity	Density (grams/ml)
3					3
22					2.65
7					2.5
10					3.4→4.2
17					5.2
5					2.7

2. Compute the loss of weight for each sample and record in the table.

3. Calculate the specific gravity of each sample by using the formula:

$$\text{Specific Gravity} = \frac{\text{Weight in Air}}{(\text{Weight in Air}) - (\text{Weight in Water})}$$

INTERPRETATION

1. Compare the numerical density of each sample with its specific gravity. Make a general statement to summarize these comparisons.

2. Why was the term "weight" used instead of "mass" in this investigation?

3. Order the specific gravities of the minerals from highest to lowest.

4. Order the densities of the minerals from the most dense to the least dense.

5. Compare the two ordered lists (Items 3 and 4). Make a statement based on the result of your comparison.

1A-27

DISTINGUISHING SIMILAR ROCKS

Sometimes minerals or rocks are so similar that it is difficult to identify them even after running several different tests. Today you will be given samples of two rocks that are difficult to distinguish from each other.

MATERIALS

rock specimens, unknown, 2
calcite sample
hydrochloric acid, dilute
glass slide
nail
penny
hand lens
streak plate
spring scale
triple beam balance
ultra-violet lamp
geiger counter
beaker
magnetic compass
medicine dropper

PROCEDURE

1. Put one or two drops of diluted hydrochloric acid on the calcite specimen. Describe what happens.

2. Test the two unknown specimens making use of all the methods of testing used up to the present time. Record the data on the chart below.

Specimen Number	Color	Streak	Hardness	Specific Gravity	Cleavage	Fracture	Luster	Other
53								
54								

INTERPRETATION

1. Write a paragraph describing each of the specimens.

2. Make a list of the properties that are similar for both specimens.

3. What dissimilar properties do the specimens have?

1A-28

NAMING MINERALS

Recently you distinguished between two minerals that were similar in appearance. Now you will attempt to name a number of minerals by putting into use all of the skills that you have been learning.

However, it is not always possible to name a rock or a mineral exactly on the basis of the evidence you are able to gather. For this reason you will make two *hypotheses* about each of the numbered specimens. A hypothesis is a first idea about an answer to a problem. It is based upon evidence that is incomplete, but that may be all that can be gathered at a particular time.

MATERIALS

minerals, set of 12
nail
penny
glass
fluorescent lamp
spring scale or
  triple beam balance
geiger counter
beaker, 250 ml
magnetic compass
streak plate
Mineral Identification Chart
hydrochloric acid, dilute
Zim. *Rocks and Minerals*

PROCEDURE

Using any or all of the testing devices provided, observe the characteristics of each specimen. Record your observations in the chart on the next page.

Number	Color	Streak	Hardness	Specific Gravity	Cleavage	Fracture	Luster	Other
21								
9								
28								
26								
13								
3								
14								
17								
10								
7								
4								
23								

INTERPRETATION

Listed by numbers in the chart below are the mineral specimens you have observed. Next to each number, write your first and second hypotheses for the name of the specimen. Make sure that your hypotheses are based strictly on the evidence you have gathered in the data chart.

Specimen Number	Hypotheses	
	Choice 1	Choice 2
21		
9		
28		
26		
13		
3		
14		
17		
10		
7		
4		
23		

1A-29

NAMING MINERALS IN ROCKS

A rock is composed of one or more minerals. You may have already formed some ideas about the minerals in the rocks that you have been collecting. Now you will have an opportunity to do some "detective work" on this rock collection. Sherlock Holmes solved mysteries in a particular way. He first looked at the obvious clues and them searched for less obvious evidence. After collecting all the information he could get, he tried to put it together in a logical way. Then he was ready to form some hypotheses concerning the identity of the criminal. He did not, however, confront the suspect with an accusation until his clues or data were sufficient to support his conclusion. You can work in similar fashion to solve the mystery of the minerals in the rocks in your collection.

MATERIALS

rock samples
nail
penny
glass slide
ultra-violet lamp
spring scale or
  triple beam balance
geiger counter
beaker, 250 ml
magnetic compass
streak plate
Mineral Identification Chart
dilute acid
Zim. Rocks and Minerals

PROCEDURE

1. Decide on the tests you want to use for gathering clues about the rocks in your collection. Design a data chart to organize the observations you will be making and draw it on the next page. Code each rock sample with a letter, using a felt-tip pen or some other marking device.

2. Using the materials provided, carry out as many tests as you need. In some cases it may not be necessary to use all of the testing materials. When you feel you have gathered enough evidence to form some hypotheses report these to your teacher. If your evidence is not complete enough your teacher will ask you to make more tests.

CHART OF OBSERVATIONS AND DATA FOR ROCK SAMPLES

INTERPRETATION

1. Complete the chart below as a summary of the "clues" and "suspects" for each of the rocks. Name no more than four possible minerals for each rock.

Rock Sample	Hypotheses for Names of Possible Minerals	Main Supporting Evidence for Each Mineral Named
A	1	
	2	
	3	
	4	
B	1	
	2	
	3	
	4	
C	1	
	2	
	3	
	4	

Rock Sample	Hypotheses for Names of Possible Minerals	Main Supporting Evidence for Each Mineral Named
D	1	
	2	
	3	
	4	
E	1	
	2	
	3	
	4	
F	1	
	2	
	3	
	4	

2. List the mineral identification tests that were most useful to you in naming the minerals in your rock collection.

APPENDIX

1. Objectives
2. Mineral Identification Chart

OBJECTIVES

Investigating Rocks and Minerals

1. Identify the appropriate sense needed to make an observation.
2. Distinguish between an observation and a non-observation.
3. Name the qualitative characteristics of objects using one or more of the senses.
4. Distinguish among objects on the basis of observable characteristics.
5. Demonstrate the ability to use instruments in making observations.
6. Demonstrate the ability to select the proper instrument to extend observations of qualitative characteristics.
7. Distinguish between qualitative and quantitative characteristics of objects.
8. Demonstrate a procedure for using the metric system to determine length.
9. Demonstrate a procedure for measuring area.
10. Demonstrate a procedure for measuring volume.
11. Demonstrate a procedure for measuring mass.
12. Demonstrate the ability to select the appropriate instrument to measure the quantitative characteristics of objects.
13. Describe qualitative and quantitative characteristics of objects.
14. Distinguish among objects on the basis of density and specific gravity.
15. Distinguish among objects on the basis of physical properties.
16. Construct a chart of paired measurements.
17. Construct a chart of paired measurements with one of the sets of measurements ordered.
18. Distinguish the dependent variable from the independent variable, given a chart of paired measurements with one of the sets of data ordered.
19. Apply the rule that the scale for the independent variable is ordered on the horizontal axis of a graph and the scale for the dependent variable is ordered on the vertical axis.
20. Identify a point on a graph, given a pair of measurements.
21. Construct a line graph of ordered pairs.
22. Construct a statement that describes a set of data.
23. Construct one or more ideas from a table and a graph.
24. Construct one or more ideas from a set of observations.
25. Identify the data that supports an idea.
26. Distinguish whether or not an idea is supported.
27. Order a set of ideas from least to most probable.
28. Construct an investigation and demonstrate the procedures to test an idea.

STUDENT MINERAL IDENTIFICATION CHART

No.	Name	Color	Luster	Streak	Hardness	Specific Gravity	Cleavage Fracture	Distinctive Characteristics
1	Biotite	Brown Black	Metallic	White	2.5-3	2.9	1 side	Cleaves in thin sheets
2	Calcite Crystal	Clear	Glassy	White	2 - 3	2.7	3 sides Conchoidal	Effervescent in acid; often fluorescent
3	Corundum	Gray *	Glassy	White	9	4	6 sides Conchoidal	
4	Garnet	Red Brown *	Glassy	White	6.5-7.5	4	3 sides Uneven	
5	Hematite	Red Brown	Dull	White	4 - 6	5	Uneven	
6	Muscovite	White	Glassy	White	2-2.5	2.8	1 side	Cleaves in sheets
7	Quartz Crystal	Colorless *	Glassy	White	7	2.6	Conchoidal	6-sided crystal
8	Tourmaline	Black *	Glassy	White	7-7.5	3	Uneven or Conchoidal	Long crystals
9	Willemite	*	Glassy	White	5.5	4	1 side Uneven	Fluorescent
10	Apatite	Green *	Glassy	White	5	3.2	Conchoidal	6-sided crystal
11	Feldspar	Pink *	Pearly Glassy	White	6-6.5	2.6	2 sides Uneven	
12	Gypsum	White	Pearly	White	1.5-2	2.3	2 sides Conchoidal	
13	Hornblende	Black	Glassy	White	5 - 6	2-3.4	2 sides	
14	Pyrite	Brassy Yellow	Glassy	Green Black	6-6.5	5	3 sides Uneven	Cubic crystals
15	Talc	White *	Pearly	White	1-1.5	2.7	1 side Uneven	Greasy to touch

No.	Name	Color	Luster	Streak	Hardness	Specific Gravity	Cleavage Fracture	Distinctive Characteristics
16	Topaz	Yellow	Glassy	White	8	3.5	1 side Conchoidal	
17	Wernerite	*	Glassy		5.5-6		Conchoidal	Fluorescent
18	Asbestos	Greenish	Pearly	White	2.5-4	2.2-2.6	1 side	Long fibers, silky
19	Calcite, Rhombic	White *	Glassy	White	2 - 3	2.7	3 sides Conchoidal	Effervescent in acid; often fluorescent
20	Galena	Gray	Metallic	Gray, Black	2.5-2.8	7.5-7.6	3 sides	Cubic crystals
21	Halite	White	Glassy	White	2.5	3	3 sides Conchoidal	Dissolves easily
22	Fluorite	Purple *	Glassy	White	4	3.2	8 sides	Often fluorescent; effervescent in acid
23	Sulfur	Yellow	Pearly		1.5-2.5	2.0-2.1	Conchoidal	Odor of rotten egg
24	Specular Hematite	Black *	Metallic	Red-brown	1.6	5.1	Uneven	Iron-bearing
25	Graphite	Black	Metallic	Black	1 - 2	2-2.3	Uneven	Greasy to touch
26	Quartz, Milky	White	Glassy	White	7	2.6	Uneven Conchoidal	
27	Obsidian	Brown Black *	Glassy	White	6	2.2-2.8	Conchoidal	
28	Magnetite	Black	Metallic	Black	5.5	5	Uneven	Natural magnet

Notes:
1. This key is a simplified chart of mineral characteristics, using many textbooks as sources.
2. An asterisk (*) in the color column indicates that the color varies.
3. An empty blank in any column indicates that the property is not distinctive for that material.

NOTES

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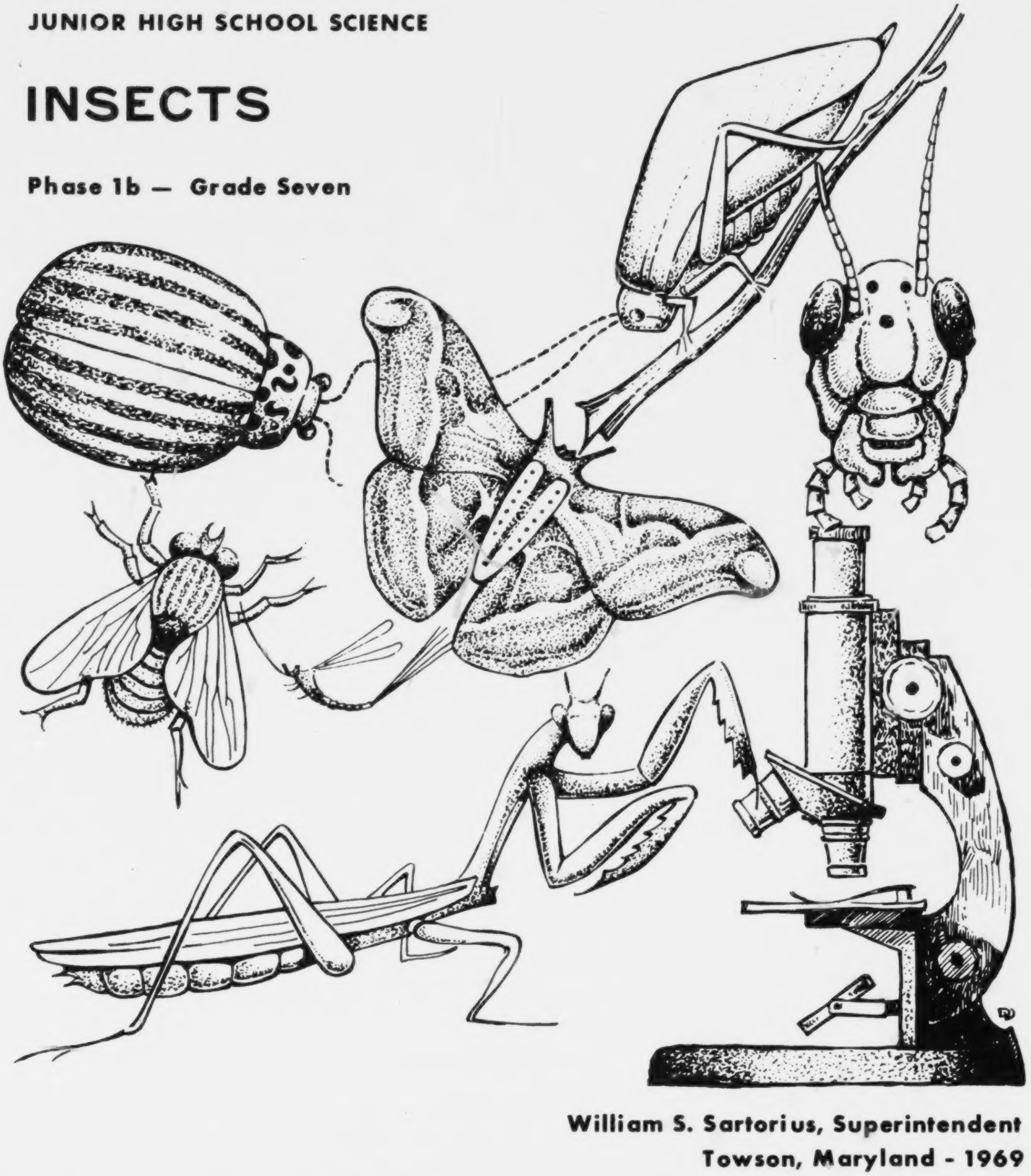
NOTES

BALTIMORE COUNTY PUBLIC SCHOOLS

A STUDENT MANUAL FOR
JUNIOR HIGH SCHOOL SCIENCE

INSECTS

Phase 1b — Grade Seven



William S. Sartorius, Superintendent
Towson, Maryland - 1969

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TO THE STUDENT

What is science? Perhaps you might answer by saying that exploring space is science. Or that inventing new machines is science. Or that experimenting with new cures for diseases is science. These answers are certainly not wrong, but each is only partly correct. Science is indeed a matter of exploring, of inventing, of experimenting. These are things that scientists do. There are other things that scientists do - for example, observing, measuring, verifying, hypothesizing, and others that may be familiar or unfamiliar to you.

Briefly, we can say that science is a way that people have developed for getting trustworthy information about all the objects and events around us. It begins with observations that can be checked by many people. And it leads to big ideas that explain how the world and the universe work.

Scientific knowledge is increasing rapidly. But the methods by which new knowledge is found have changed surprisingly little. Modern scientists deal with problems in much the same way scientists have gone about their work for several centuries. Of course modern scientists have many more instruments to help them make accurate observations and they have computers to help them solve problems.

You have no doubt yourself used methods of science to solve problems, probably without realizing you were doing so. You look at things, listen to them, smell them, and touch them. You discuss such observations with your friends, sharing your observations, and comparing yours with theirs. You may check your observations by reading what others have written about their observations. You make guesses about things you do not understand. And then you check your guesses by looking, listening, smelling, touching, discussing, and reading some more. When you think you have gathered enough information about a problem you decide on a possible answer. The scientist would say that you have observed, hypothesized, collected data, and come to a conclusion. These are some of the processes of science.

This year, you will learn to make better use of the processes of science. You will discover much knowledge that will be new to you. You will also use scientific methods to communicate your knowledge to others. And you will learn some basic principles of science that will help you understand how scientists explain the natural world. The science course you are about to begin is called "A Search for Structure." Most of your class time will be spent in laboratory work: conducting investigations, collecting data, recording data, and discussing your findings with others. This is not only a useful way to study science but, as noted before, it is also the way in which scientists themselves work.

In Phase 1 of this course you will develop scientific processes and skills that you can use throughout your study of science. You will learn to observe carefully, to use instruments to extend the powers of your senses, to organize observations or data in charts and graphs, to evaluate data to see what it indicates, to invent ideas that explain the data, and to experiment in order to test your ideas. By the end of Phase 1 you should be able to make clear statements about what you really observe. You will not be quick to answer a question until you have carefully gathered and looked at the evidence that relates to it.

In Phases 2 and 3 of the course you will reuse the skills you have gained in Phase 1 to study, first the structure of non-living things, and then the structure of living organisms.

THE SEARCH

Scientists are constantly trying to get answers to questions. To find these answers they must observe. You probably think of observing as seeing, but observing can be much more than seeing. When you observe you may use any or all of your senses. At times you may use instruments to help your senses. In this first investigation you will use as many senses as possible to make some observations.

PROCEDURE

1. Observe the diagrams on Page 2 and answer the following questions:

    a. In Figure 1, are AB and CD parts of a continuous straight line?

    b. In Figure 2, which is the widest, BD or AC?

    c. In Figure 3, are the vertical lines parallel?

    d. In Figure 4, which line is longer, A or B?

2. Make as many observations as you can of the object that the teacher will place before you. List your observations.

3. Select any object in the room (except people). List as many observations of this object as you can. In a few minutes you will be asked to read your list to the class. From your description the class should be able to identify the object.

Figure 1:

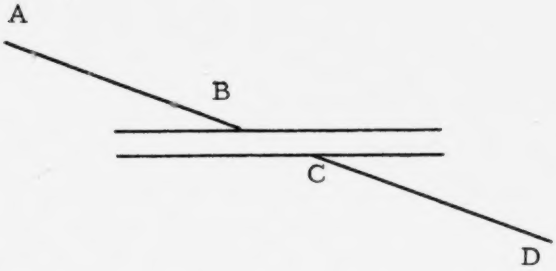


Figure 2:

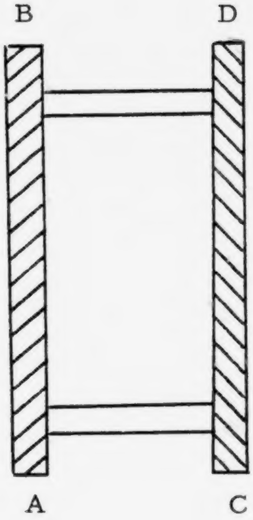
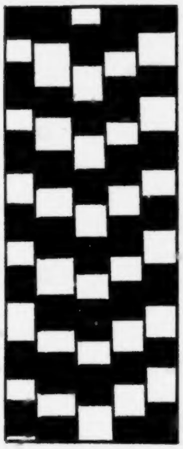


Figure 3:



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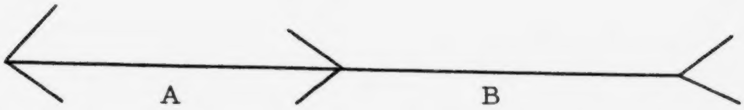


INSECTS INVADE FARM

Suppose the following news item appeared in a local county paper:

> CORN CROP DESTROYED BY INSECTS
>
> Last week several farmers found their corn fields almost completely destroyed by insects. The county agent captured several of the insects and sent them to the agricultural laboratory to be studied . . .

The insect you will be given was found in one of the corn fields.

MATERIALS

insect

PROCEDURE

1. Observe the insect and list as many observations as you can.

2. As observations are listed on the board, compare your observations with those of other members of the class.

INTERPRETATION

1. List observations that were made by the majority of the class.

2. Which of your senses did you and other members of your class use in making your observations?

3. Why were some lists of observations longer than others?

4. Do you think the insect you examined might have been responsible for the damage to the corn crop? Why?

RELATED ACTIVITY

If you had a living specimen of an insect you could make many more observations. Tomorrow bring to class one or more living insects in a small jar covered with a lid that has a few air holes punched in it.

OBSERVING INSECTS

You have had an opportunity to observe a preserved insect. However, a scientist studies both living and preserved insects. Many times it is necessary to study the living habits of an organism to determine how to control it. Today you are going to observe a live insect.

MATERIALS

live insect
container

PROCEDURE

1. Observe your living insect. List as many observations as you can.

2. Your teacher will display a large insect at the front of the room. List observations that you can make from the place where you are sitting.

INTERPRETATION

1. When you observed the living insect, what were you able to see that you did not see when you observed the preserved specimen?

2. Examine your list of observations from Item 2 of the procedure. Compare it with lists made by others. Then list any things that you are not sure you actually observed.

3. Why is it important that a scientist record only those things that he actually detects with his senses?

4. How would you define "observation"?

WHAT IS AN INSECT?

More than 750,000 kinds of insects are known to scientists. Many are among the most injurious of all animals to man's welfare and property. Fortunately most insects are harmless and some are of great benefit to man. Insects are the most numerous animals in the world today. But what does a scientist mean when he says an animal is an insect?

MATERIALS

preserved grasshopper
diagram of grasshopper

PROCEDURE

1. Examine the structure of the preserved grasshopper. List as many parts as you can, using whatever names you think appropriate. Underline characteristics common to all the insects you have observed.

2. Now look back at your sheets for Investigation 1B-3. In the list above place a check mark in front of each structure that you also observed in Investigation 1B-3.

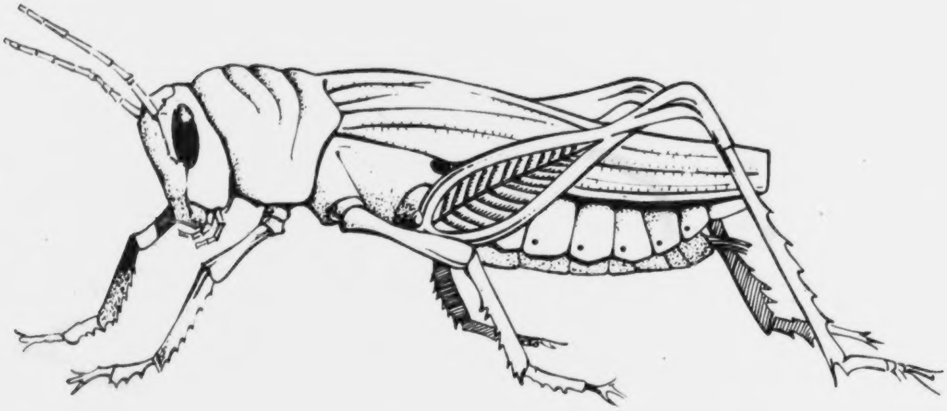
3. Read Pages 60-63 in Thurber and Kilburn, Exploring Life Science, to find out some of the terms that scientists use in describing the structure of insects.

4. On the diagram of a grasshopper, Page 8, label the following parts: head, thorax, abdomen, wing, antenna, mouth, compound eye, and leg.

5. On your preserved grasshopper, locate the parts you have labeled.

INTERPRETATION

List four characteristics that you would expect to find in all insects.



1B-5

CHARACTERISTICS OF INSECTS

Insects differ greatly in appearance, size, and shape. How does a scientist decide that a particular specimen is an insect? In other words, what characteristics are shared by all the animals in the set "insects"?

PROCEDURE

There are many ways in which insects are alike. Read Pages 60-65 in *Exploring Life Science* to discover some of the basic characteristics of insects. After reading, complete the following:

1. The exoskeleton of an insect is most similar in its function to what part of man? Circle the correct letter.

   a. muscles   b. bones   c. ligament   d. skin

2. Why is it necessary for a grasshopper to shed its exoskeleton?

3. Some parts of a grasshopper serve the same function as certain parts of man. With this idea in mind, select the letter of the word in Column B that you think corresponds to the word in Column A.

Column A: Man	Column B: Grasshopper
______ 1. hands	a. palps
______ 2. ears	b. mandibles
______ 3. tongue	c. thorax
______ 4. body	d. abdomen
______ 5. legs	e. feelers
______ 6. mouth	f. appendages
	g. head

4. All of the statements listed below are true except one. Circle the letter of the one false statement.

   a. Grasshoppers have five eyes.
   b. Grasshoppers breathe through their nose and mouth.
   c. Palps are "tasters."
   d. Antennae are sensitive to odors and sounds.

5. Spiracles are to grasshoppers as _____ are to people. Place the correct letter in the blank.

   a. heart
   b. lungs
   c. stomach
   d. intestines

6. The reading supports all of the following ideas except letter _____.

   a. Many insects have specialized organs.
   b. Insects go through different stages of development.
   c. Insects must live on the land.
   d. There are many kinds of insects.

7. Study the picture on Page 64. Without rereading the page, try to complete the following chart.

Insect	Name of Specialized Organ	Function
1. Beetle		
2. Praying mantis		
3. Moth		
4. Fly		

8. Two boys were discussing the picture at the top of Page 67. One remarked that all the animals in the picture were insects but the other boy disagreed. Which boy would you agree with? Why?

INSECT COLLECTING

Insect collecting is something like hunting. Good insect collectors and good hunters both know the ways of the animals they are looking for. They both know the places where the animals live. And they both have the proper equipment. Now that you are able to distinguish insects from other animals you should be able to make your own collection of insects.

MATERIALS

paper cup and lid
collecting net
glue
insect pins
paper funnel

PROCEDURE

1. Use the paper cup and lid as a collecting container.

2. Keep a record in your notebook of each specimen you collect. The record should contain the following information:

   Name of Insect
   Where Caught
   Date
   Collector's Name

3. Collecting techniques:

   a. The most common method of collecting insects is netting. Try to net insects when they are resting on plants; this is easier than chasing flying insects.

   b. When netting an insect that is likely to fly, aim the lower edge of the net just below it. Net the insect with a sideward or upward swipe. As you come to the tip of your swing, flick your wrist so that the tip of the net flaps over the ring.

   c. When collecting in grassland, sweep your net back and forth in the grass. Examine your net about every dozen sweeps.

   d. To place the insects in the collecting container lay it on its side, remove the lid and insert a paper funnel into the opening. Place the mouth of the net over the paper funnel. Flip the tip of the net open so that the insects can go into the container. When all the insects have entered the collecting container, remove the funnel and replace the lid. Do not put moths and butterflies in the same container with other insects.

e. To kill the insects place your collecting container in a freezer for about five minutes. In the food chamber of a refrigerator it takes up to twenty-four hours for insects to die.

4. Pinning and storing insects:

To learn the proper technique for pinning and storing your insects, read pp. 53-54 in Exploring Life Science by Thurber and Kilburn.

INTERPRETATION

1. Why do you think butterflies and moths should be stored separately from other insects?

2. What advantage is there in killing insects in a freezer rather than with chemicals?

3. How might the collecting of insects help you to learn about insects?

4. How might a collection of mounted insects be used to help you learn about insects?

PILL BUGS IN A PILL BOX

When you were collecting insects you probably observed that different insects behaved in different ways. In the laboratory a scientist can study the behavior of an animal much more easily than he can in the field. Today you will make a laboratory study of behavior, using for your investigation a small gray animal called a pill bug.

MATERIALS

small plastic box
paper towels
scissors
water

black paper
transparent tape
pill bugs, 5

PROCEDURE

1. Place the plastic box on a paper towel and outline its shape and size with a pencil.

2. Cut out the shape and fit it into the inside of the bottom of the plastic box.

3. Add enough water to make the towel slightly moist.

4. Cover one-half of the outside of the box with black paper. Use transparent tape to attach the black paper.

5. Put five pill bugs in the plastic box and place the lid on the box.

6. Place the box in a well-lighted area and allow it to remain there for five minutes. At the end of that time record on the first line of the chart the number of pill bugs in the lighted area and the number in the dark area.

7. Record on the following lines of the chart the data obtained by four other student groups. Find the average by adding each column and dividing by five.

Student Group	Dark Area	Light Area
My Group		
Group #1		
Group #2		
Group #3		
Group #4		
Totals		
Averages		

8. Examine one of the pill bugs.

How many legs does it have? ____________

How many antennae does it have? ____________

How many body regions does it have? ____________

How many wings does it have? ____________

INTERPRETATION

1. Write a statement that describes the usual response of pill bugs to light.

2. Considering the behavior you have observed, where would you expect to find pill bugs living? Explain.

3. Refer to Investigation B-4. Is the pill bug an insect? Explain.

RELATED ACTIVITY

In Thurber and Kilburn, Exploring Life Science, read Pages 72-73. Compare the investigation described there with the one you performed.

A CLOSER LOOK AT INSECTS

You have learned that the information used by scientists is obtained by observing. But observing depends upon sense organs and sense organs are limited in their abilities. Therefore, scientists depend upon instruments to extend their abilities to observe. Some of these instruments are very complicated but others are simple. By using a simple magnifying glass (or hand lens) you can make many more observations of small objects than you can make with the naked eye.

MATERIALS

hand lens	Thurber and Kilburn, Exploring Life Science
insects, 2	
ruler	

PROCEDURE

1. Without using the hand lens, observe the two insects. Make drawings of each one as close as possible to actual size.

   Insect #1 Insect #2

2. Now use the hand lens to observe the insects. Make a drawing of each of them the size they now appear to be and add any details that were not visible before.

   Insect #1 Insect #2

3. Determine the magnification of the hand lens by estimating how many times larger the drawings in Item 2 are than the drawings in Item 1.

4. In Exploring Life Science, look at the sketches of the grasshopper at the top of Page 60 and the bottom of Page 61. Using a metric ruler, measure each drawing from the head to the end of the body. From your measurements estimate how many times the one sketch is larger than the other.

INTERPRETATION

1. List at least two advantages of using a hand lens to observe small insects.

2. Name other instruments that have lenses and are used to enlarge (magnify) the appearance of objects.

THE PARTS OF A MICROSCOPE

You have discovered that a hand lens can be used to magnify the appearance (image) of objects. Suppose you wanted to enlarge the image of an object still more. To do this a scientist would use a microscope. Its proper use, care and handling are skills that will aid you in carrying out many future investigations. In order to acquire these skills you must first learn the names of the parts of a microscope and their functions.

MATERIALS

hand lenses, 2
microscope

PROCEDURE

1. A microscope is composed of several lenses set in a tube. In this investigation you will discover the advantage of using a combination of lenses.

    a. Using one hand lens only observe the letters in the first line of the chart below. Draw each letter in the space next to it just as it appears to you through the hand lens.

    b. Place one hand lens on top of another lens so that you can use the two lenses together. Observe the letters in the second line and draw them.

One lens	E		E	
Two lenses	E		E	

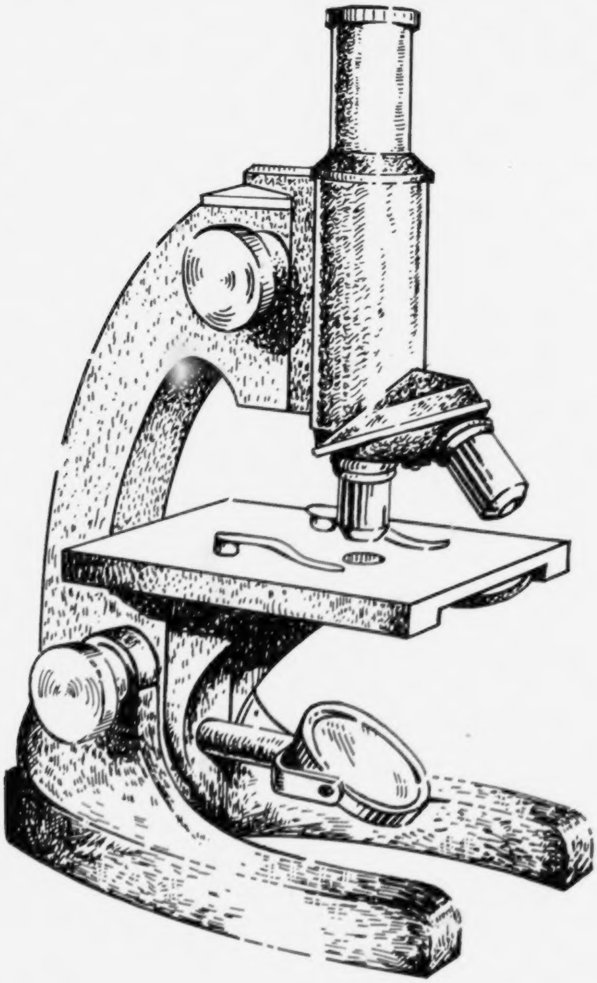
2. Study the chart and estimate the magnification of one lens and two lenses.

    magnification of one lens: ____________________

    magnification of two lenses: ____________________

3. A microscope makes use of several lenses to achieve greater and clearer magnification. Read Pages 525-526 in Life: Its Forms and Changes to learn about the parts of a microscope.

4. Label the parts of the microscope in the diagram below.



5. Microscopes are not all exactly alike. Examine the microscope that you have in front of you. Compare each of its parts with the parts in the picture on Page 527 of Life: Its Forms and Changes.

6. Watch as your teacher demonstrates the use of your microscope. Then complete the chart below by recording the function of each microscope part.

Microscope Part	Function
a. lenses	
b. mirror	
c. diaphragm	
d. coarse adjustment	
e. fine adjustment	
f. stage and clips	

7. Compute the magnification for both low and high power of your microscope.

low power magnification ____________________

high power magnification ____________________

INTERPRETATION

1. What is the advantage of using two hand lenses rather than one lens?

2. What are the advantages of using a microscope rather than two hand lenses?

1B-10

LEARNING ABOUT THE MICROSCOPE

The microscope is probably one of the most important single tools used by scientists. To learn more about insects you need to become familiar with the care and proper use of this instrument. In this investigation you will view a filmstrip, Using the Microscope - Part I, demonstrating the proper use, care and handling of the instrument.

PROCEDURE

1. Four filmstrip frames will be shown to you. As you observe them fill in the items below:

   a. Frame 1: Describe the proper method for carrying a microscope.

   b. Frame 2: Why is the mirror movable?

   c. Frame 3: What is the purpose of the diaphragm on a microscope?

   d. Frame 4: Describe the safety procedure shown in this frame. Why do you think this is necessary?

2. Now you will view the entire filmstrip. When you have done so, complete the following:

   a. Correct this statement.

   > A microscope lens may be wiped clean with any type of cloth or paper.

b. State the rule you should use when viewing a moving organism through a microscope.

c. Explain what might be wrong when an image is not in sharp focus under a microscope.

d. What do you do when you lose an organism under high power? Circle the best answer.

(1) Move the slide around.
(2) Adjust the light.
(3) Make further adjustments with the knobs.
(4) Change back to low power.

e. Arrange the steps in the preparation of a wet-mount slide by numbering from 1 to 3.

____ Place drop of water on slide.
____ Place specimen on slide.
____ Place cover slip on slide.

f. Arrange the steps in observing a specimen under high power by numbering from 1 to 6.

____ Sharpen the image with the fine adjustment.
____ Center the specimen.
____ Focus with the coarse adjustment.
____ Lower the low power objective.
____ Switch to high power.
____ Adjust for proper light.

USING A MICROSCOPE

Now that you are familiar with the microscope, you will have an opportunity to use one.

MATERIALS

"e" from newspaper
microscope slide
medicine dropper
water
cover slip
microscope

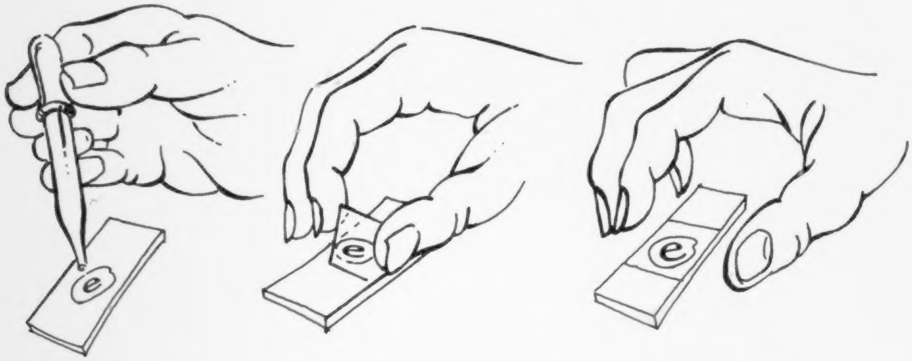
PROCEDURE

1. Preparing a wet mount

   a. Place the paper containing an "e" upright in the center of a microscope slide.

   b. Put one drop of water on the "e." (See diagram.)

   c. Place a cover slip over the "e."



2. Focusing:

   a. Place the prepared slide on the stage of the microscope under the low-power objective. Move the slide until the letter "e" is centered over the opening in the stage.

   b. Use the coarse adjustment to lower the body tube until the low-power objective stops. (CAUTION: In some old microscopes there is no stop and the low-power objective can be lowered until it hits the slide. If you have such a microscope you must watch the objective and stop it just above the slide.)

c. As you look through the eyepiece, keep both eyes open. This is difficult at first, but you can soon learn to do it.

d. Set the diaphragm at its largest opening. Adjust the mirror until the field is evenly and brightly lighted.

e. While looking through the eyepiece, slowly turn the coarse adjustment to raise the body tube until the printed letter comes into view. Then turn the fine adjustment to make the focus as sharp as possible.

f. If the light is too great, reduce it by adjusting the diaphragm. Find the position where the amount of light coming through gives you the greatest clarity.

3. Observing:

a. Draw the letter "e" as it appears to your naked eye. (That is, without the microscope.)

b. Draw the letter "e" as its image appears when viewed through the microscope.

c. Move the slide away from you. In what direction does the image of the letter "e" move?

d. Move the slide to the left. In what direction does the image of the letter "e" move?

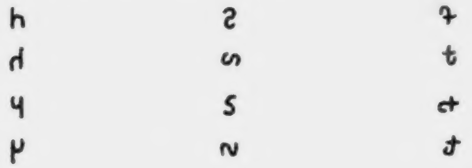
e. Rotate the slide in a clockwise direction. In what direction does the image of the "e" move?

f. Change to high power. Describe any differences in the field-of-view and the light intensity.

CAUTION: In all microscopes the high-power objective may be lowered enough to hit the slide. Therefore, when lowering the high power objective, always watch the objective from the side. Never lower it while you are looking through the eye-piece.

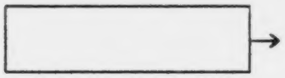
INTERPRETATION

1. Suppose you had the letters, "h", "s", and "t" on a slide. In each of the columns below circle the drawing that shows how one of the letters would appear through the microscope.

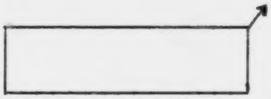


2. Suppose you were viewing an insect and its image began moving in the direction of the arrow: (→) Circle the letter of the drawing that shows the direction you must move the slide in order to get the insect back into the field-of-view.

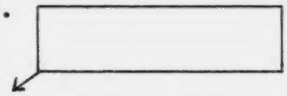
a.



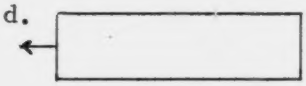
b.



c.



d.



3. If an object under a microscope is moved counter clockwise, which way does its image move?

RELATED ACTIVITY

1. Prepare a new wet mount of a material suggested by your teacher and view it under the microscope. Sketch what you see.

2. Make sketches of an insect wing as viewed in the three following ways:

   a. Unaided eye

   b. Hand lens

   c. Microscope

STEREOSCOPIC MICROSCOPE

Some things are too small to be seen clearly with the unaided eye but too thick to be seen properly with the kind of microscopes you have been using. This is true of most insects. For such objects the stereoscopic microscope can be used.

MATERIALS

newspaper containing letter "e"
slides
medicine dropper
stereoscopic microscope
cover slips
fruit fly

PROCEDURE

1. Examine the stereoscopic microscope and try to identify the following parts:

   eyepiece lens
   low objective lens
   focus adjustment
   stage

2. Compute the magnification of a stereoscopic microscope using the data below.

Eyepiece	Objective Lens	Magnification
10X	1.5	

3. Make a wet mount of a small "e" from a newspaper.

4. Examine the slide and answer the following questions:

   a. How does the image compare with the actual letter?

   b. How does this image compare with the view of the "e" as seen through the microscope you used before?

   c. When the slide is moved from right to left, which way does the image move?

5. Observe a fruit fly with the unaided eye. Try to determine the number of stripes on its abdomen. Sketch below.

6. Observe a fruit fly with the stereoscopic microscope. Try to determine the number of stripes on its abdomen. Sketch below.

INTERPRETATION

1. Suppose you were observing the letter "d." Show below how it would appear through a stereoscopic microscope and through an ordinary microscope.

stereoscopic microscope	ordinary microscope

2. Which kind of microscope (ordinary or stereo) provides the larger magnification?

3. Which microscope would you use to examine the following:

_________________ a. housefly

_________________ b. grasshopper leg

_________________ c. fruit fly wing

_________________ d. beetle

_________________ e. drop of pond water

RELATED ACTIVITY

1. Look at a prepared slide of three layers of thread. Identify the colors of the three layers:

   a. The lowest thread is ________________.

   b. The middle thread is ________________.

   c. The top thread is ____________________.

2. Place several salt crystals on a slide. Make sketches as indicated.

   a. Unaided eye b. Stereoscopic microscope

MEASURING LENGTH

Microscopes enable you to make detailed observations. But observations to to useful to scientists must be verifiable - that is, it must be possible for other observers to check them. As an observer you report that a certain insect is large, short, heavy and slow. But do these terms mean the same to another observer as they mean to you? To communicate such ideas accurately some system of measurement must be agreed upon. To make measurements all scientists have adopted the metric system, which is also the system used by non-scientists in most parts of the world.

MATERIALS

meter stick

PROCEDURE

The basic unit of length in the metric system is the meter. The word meter comes from the Greek word meaning "measure." The abbreviation for meter is m. Three other common units of length in the metric system are:

decimeter
centimeter
millimeter

What root word appears in all of these? ____________________ The names of the units of length in the metric system contain this root word together with a prefix.

1. In the chart below list the prefix of each unit and try to determine its meaning.

Word	Prefix	Meaning
a. decimeter		
b. centimeter		
c. millimeter		

If you are unable to complete this chart now, complete it after you have learned more about the metric system.

2. In the metric system you can find the size of a unit by looking at its prefix. In our decimal system of numbers, how many does each decimal place represent?

3. Then how many decimeters do you think there are in a meter?

4. A centimeter relates to a meter as a cent does to a dollar. How many cents are in one dollar?

5. Then how many centimeters do you think there are in a meter?

6. It is not always possible to make correct guesses from the meaning of words. You might very well be led astray by the word "millimeter." So look now at a meter stick. Notice the distance from the left end of the stick to the first number. This is one of the units. How many of these units are there in the whole length of the meter stick? ________ What is the name of this unit? ____________________ What is the name of ten such units? ____________________

7. Notice that each centimeter is divided into ten smaller units. Each of these is a millimeter. How many millimeters are there in a meter?

8. Now use your meter stick to measure the distance between each of the points shown on the following page. Record your results below, using the designated units of the metric system.

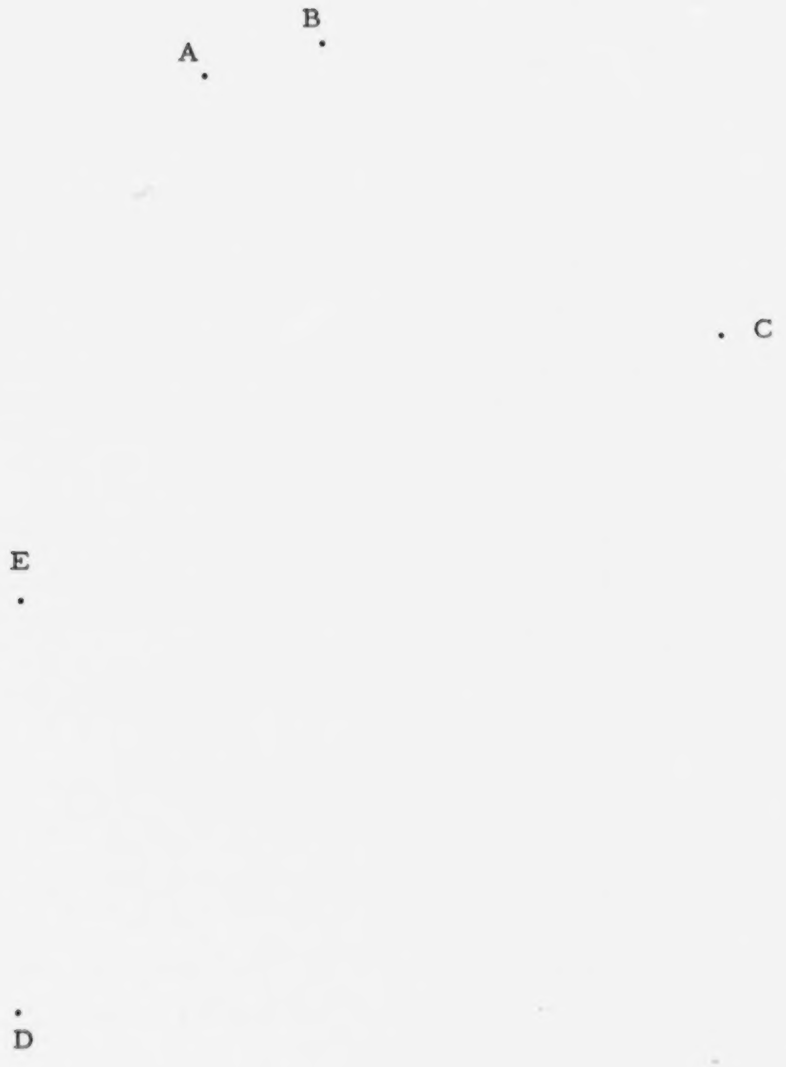
A to B = ______________ mm

A to C = ______________ cm

B to E = ______________ cm

D to C = ______________ mm

D to C = ______________ cm

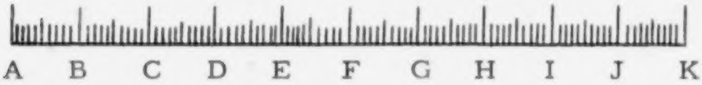

B
A
C
E
D

INTERPRETATION

1. On the scale below,the distance from A to K is one ________________.

   From A to B, B to C, and so on, each unit is one ________________.

   Each of the smallest division marks represents one ________________.

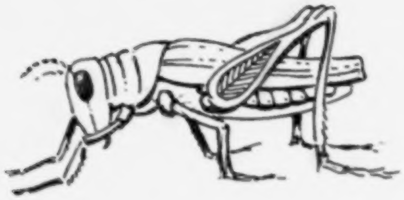


2. The distance from A to F is ____________________ of a decimeter.

3. Complete this chart:

Unit	Abbreviation	Part of a Meter
decimeter		
	cm	
		1/1000

4. This is a descendant of the celebrated hopper from Cavendish County. For every meter he can jump, he earns $1.00. Paid at the same rate, how much will he earn for jumping one decimeter?



LENGTH OF GRASSHOPPER LEGS

You have learned some of the units of length in the metric system. How might a scientist use length units to report his observations accurately? In the following investigation you will measure the lengths of grasshopper legs to determine whether or not there is a relationship between the lengths of the individual segments of a leg and the total length of the leg.

MATERIALS

grasshopper
metric ruler

PROCEDURE

1. Using a metric ruler measure the hind legs of a grasshopper. Measure each of the three segments of each leg. Record your results in the chart below. ("Upper" refers to the segment closest to the body.)

	Length of Hind Legs in Millimeters			
	Upper Segment	Middle Segment	Lower Segment	Total Length of Three Segments
Right Hind Leg				
Left Hind Leg				

Add across each line and place calculated total lengths in the last column of the chart.

2. Measure the length of the middle pair of legs of the same grasshopper. Record your results in the chart and calculate the total lengths.

	Length of Middle Legs in Millimeters			
	Upper Segment	Middle Segment	Lower Segment	Total Length of Three Segments
Right Middle Leg				
Left Middle Leg				

3. Measure the length of the front pair of legs of the same grasshopper. Record your results in the chart and calculate the total lengths.

	Length of Front Legs in Millimeters			
	Upper Segment	Middle Segment	Lower Segment	Total Length of Three Segments
Right Front Leg				
Left Front Leg				

INTERPRETATION

1. What relationship exists between the length of the upper segment of each leg and its middle segment?

2. Measure directly the total length of one hind leg and compare this measurement with the calculated total from the first chart.

   a. Are your results the same? Explain.

   b. What difficulties did you have while measuring the three segments at once?

RELATED ACTIVITY

Demonstrate a way to measure the length around the abdomen of a grasshopper. The only measuring scale available is a ruler.

1B-15

BREATHING RATE OF AN INSECT

The insect world is full of activity. The amount of activity is often affected by an insect's environment. One important environmental factor that affects an insect's activity is temperature. To study the effect of temperature changes the scientist must know how to measure temperature. In this investigation you will measure temperature to discover how it affects the breathing activity of an insect.

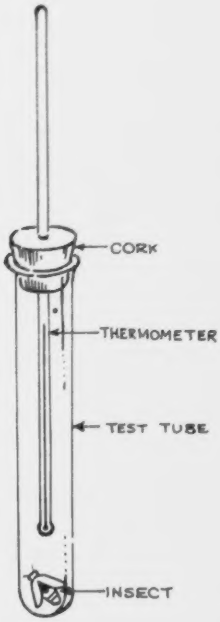
MATERIALS

ice cubes, 3
beaker, 250 ml
water
large test tube
cork stopper
thermometer
live insect
stirring rod
heat source
stand
asbestos pad
timer

PROCEDURE

1. Place three ice cubes in a beaker and add water until the beaker is about 2/3 full.

2. Set up the apparatus shown below.



3. On the first line of the chart below record the temperature of the air in the test tube. Then count the number of times the insect breathes during one minute at that temperature. Each time an insect breathes you can see its abdomen contract and expand. Make several practice counts. Record your final count on the first line of the second column of the chart.

Temperature (°C)	Number of Breaths in One Minute

4. Put the test tube in the beaker. Stir the ice and water mixture. It will take three to five minutes for the termperature of the air inside the test tube to equal the temperature of the ice water in the beaker. How can you determine when the temperatures have nearly equalized without measuring the temperature of the water?

5. When the temperature of the air inside the test tube remains constant for two minutes record that temperature on the second line of the chart. Count the number of times the insect breathes in one minute. Record the count.

6. Remove the test tube from the ice water and empty the beaker.

7. Pour water into the beaker until it is 2/3 full. Set the beaker on a stand and heat the water until the temperature is between 30°C and 45°C. Remove the beaker from the burner stand.

8. Place the test tube in the warm water. When the temperature of the air inside the test tube remains constant two minutes, record the temperature of the air on the third line of the chart. Count and record the number of times the insect breathes in one minute.

INTERPRETATION

1. Why should you wait until the temperature of the air inside the test tube is constant before counting the number of times the insect breathes?

2. At what temperature was the insect's breathing rate greatest?

3. At what temperature was the insect's breathing rate lowest?

4. Write a statement that summarizes the effect of temperature on the breathing rate of an insect.

5. Predict the insect's breathing rate for a temperature of 90°C. How might you check your prediction?

RELATED ACTIVITY

Cut a piece of paper to fit the bottom of a pie pan. Starting at the center of the paper, mark the paper with concentric circles placed an inch apart. Place a crawling insect in the center of the pan and measure the speed with which it moves at different temperatures.

1B-16

EXTENDING OUR SENSES

You have used a hand lens, two kinds of microscopes, a metric scale, a timer, and a thermometer to help you make observations and report them accurately. There are a great many other tools that a scientist may use to extend his senses. For each investigation he must choose the best instrument for the job. In this investigation you will select the best instrument for each observation and then use that instrument.

MATERIALS

metric ruler
microscope
slide
stereoscopic microscope
stop watch
hand lens
fruit flies
plastic tube
scalpel
insects (preserved and live)
petri dish

PROCEDURE

Above are listed the instruments available to you. Below you are asked to make certain observations. Select the best instrument to carry out each observation. In each case name the instrument or instruments you select and then make and record your observations.

1. Measure the length of a hind leg of an insect.

2. Measure an antenna.

3. Diagram two segments of the abdomen and show the location of the spiracles.

4. Examine the head of a preserved grasshopper and locate the three simple eyes. Diagram the head and include the three simple eyes.

5. Examine the compound eye of the grasshopper and draw several facets.

6. Make a diagram of a small section of the wing of a fruit fly to show the arrangement of the veins.

7. What is the color of the eyes of a fruit fly?

8. Record the length of time it takes an insect to travel the length of a plastic tube.

INTERPRETATION

1. What instrument would you use to:

_______________ a. observe bacteria?

_______________ b. measure the length of a mouse?

_______________ c. measure the time it takes a mouse to go through a maze?

_______________ d. examine the parts of a small flower?

_______________ e. observe a grain of salt?

_______________ f. observe a bean seedling?

2. Why does a scientist use instruments?

RELATED ACTIVITY

1. Select any scientific instrument and prepare a written report on it. This report should include the discovery and development of the instrument, the operation of the instrument and some situations where the instrument would be used.

2. Using the rate at which your insect traveled in Item 8 of the Procedure, calculate how long the insect would take to travel around the earth at the equator.

1B-17

HOW BIG IS THE CAGE?

Several boys who collect insects were building cages to hold them. They wanted the inside of each cage to be big enough to hold 10 grasshoppers. They read that each grasshopper needed a space of about 200 cubic centimeters and wondered, "What's a cubic centimeter"?

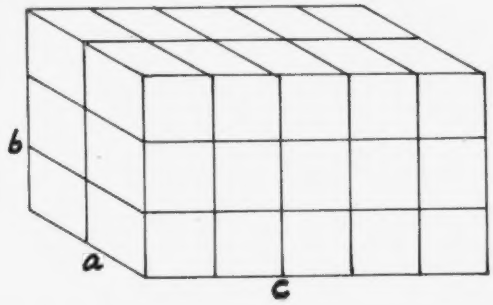
PART A

MATERIALS

cubes, 30

PROCEDURE

1. Using the cubes, construct a rectangular solid like the one below. Call this Solid #1. Count the number of cubes you used to construct the solid and record in the chart on the next page. Then count the number of cubes along each of the edges of the rectangular solid and record these counts in the same chart.



2. Using a different number of cubes, construct a second rectangular solid. Call this Solid #2. On the second line of the chart record the required information. Then use another number to construct a third rectangular solid, Solid #3, and complete the chart.

3. Multiply the numbers of cubes counted along each of the edges to get a product for each solid and record your answers in the last column of the chart. For example, if Edge a is 2 cubes, Edge b is 3 cubes, and Edge c is 4 cubes, then 2 x 3 x 4 = 24.

	Total Number of Cubes Used to Construct Rectangular Solids	Number of Cubes Used			a x b x c
		Edge a	Edge b	Edge c	
Solid 1					
Solid 2					
Solid 3					

INTERPRETATION

1. Is the product of the number of cubes on each side larger than, less than, or the same as the number of cubes you used to construct the solid?

2. If you know the linear measurements of the length, width, and height of a rectangular solid, how can you find the volume of that solid?

PART B

MATERIALS

metric ruler
rectangular solids, 6 samples

PROCEDURE

1. Measure the length, width, and height of the six numbered rectangular solids. Let the longest measured side of the rectangular solid be called the length. Record your measurements in centimeters in the chart on the next sheet.

Samples	Length	Width	Height	Volume = L x W x H
#1				
#2				
#3				
#4				
#5				
#6				

2. Calculate the volume of each solid. Give the name of the unit of each measurement.

INTERPRETATION

Compare your measurements of the volumes of the rectangular solids with those of another student. Are your values for the volumes of these solids the same as those of the student with whom you compared? If not, how can you account for any differences?

1B-18

GRASSHOPPERS AND VOLUME

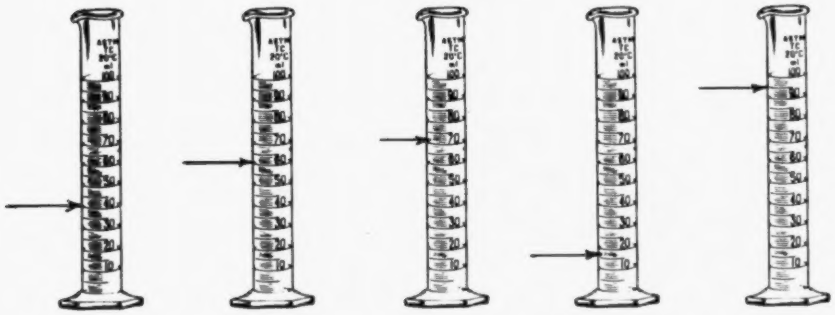
You have found that the volume of a rectangular object may be calculated by multiplying the length times the width times the height. The volumes of some other objects may also be calculated from linear measurements. Many times, however, it is necessary to find the volume of an irregular solid. Suppose, for example, that a scientist needs to know the volume of a grasshopper.

MATERIALS

graduated cylinder
preserved grasshopper

PROCEDURE

1. Observe the graduated cylinders in the sketches below. If each cylinder contained a liquid to the level of the arrow, name the amount by placing a number in the blank below it.



________ ________ ________ ________ ________

A B C D E

2. The numbers on a graduated cylinder are in metric units called milliliters (abbreviated ml). For most purposes a ml can be considered to be equivalent to a cc. Pour 50 ml of water into your graduated cylinder. Have another student check your accuracy.

3. Describe below what you think would happen if you placed the preserved grasshopper in the graduated cylinder of water.

4. Place the insect in the graduated cylinder to test your idea. Describe below what happened.

5. Using the end of a pencil, push the insect entirely beneath the surface of the water. How does the new height of the water compare to the original height before the insect was placed in the water?

6. What caused the change?

7. It is difficult to use a formula to find the volume of an irregularly shaped object such as an insect. To measure the volume of such an object, scientists place it in a known volume of water and observe the increase in volume. This increase represents the volume of the object.

INTERPRETATION

1. The following chart contains a set of data collected by placing insects in graduated cylinders of water and recording the changes in water level. Complete the chart.

Graduated Cylinder	Level without Insect (ml)	Level with Insect (ml)	Change in Water Level	Volume of Insect
A	30	32		
B	17	20		
C	29	35		
D	15	16		
E	75	102		
F	82	91		

2. How did the insects in the preceding chart compare in size? You can show this by placing in a list the letters representing the insects, beginning with the one that represents the insect with the greatest volume and ending with the one that represents the smallest. This process is called "ordering." Now order the letters from the chart on the previous page to show this.

3. Name five objects, other than insects, whose volume must be determined by using the method that you used for the grasshopper.

1B-19

FOOD MASS

To keep insects alive in a laboratory it is necessary to provide food for them. Fruit flies, which you have previously observed, are easily kept if given food. It is necessary, however, to measure the ingredients accurately because if the food is too moist the flies may drown and if it is not moist enough the flies' bodies may dry out. You can measure the water in the food by using a graduated cylinder. But for the other material you must learn how to measure mass by using a triple beam balance.

MATERIAL

- triple beam balance
- dime
- penny
- nickel
- fruit-fly food
- culture bottle
- beaker with water, 250 ml
- graduated cylinder
- glass stirring rod
- dry yeast
- stopper

PROCEDURE

1. Your teacher will demonstrate the correct use of a triple beam balance. The metric unit used for the measurement of mass is the gram (abbreviated g). Watch the procedure carefully and list the steps used.

2. Now use a balance yourself to determine the mass in grams of a dime, a nickel and a penny.

Coin	Mass (g)
Dime	
Nickel	
Penny	

3. Using a triple beam balance, measure 14 grams of fruit-fly food and place it in the culture bottle.

4. Using a graduated cylinder, measure 50 ml of water. Add the water to the dry fruit-fly food and stir.

5. Sprinkle a thin layer of dry yeast on the surface of the food and then stopper the bottle.

INTERPRETATION

In the kitchen which kind of measurement is most frequently used? Circle the letter in front of your choice.

a. volume measurement
c. linear measurement
b. mass measurement
d. area measurement

REARING FRUIT FLIES

Now that you have prepared food, you are ready to rear some fruit flies. To start you will be given some adult fruit flies that have been "put to sleep" or, as a scientist would say, anesthetized.

MATERIAL

fruit flies
hand lens
small brush
paper towel
metric ruler
scissors
bottle of food
label

PROCEDURE

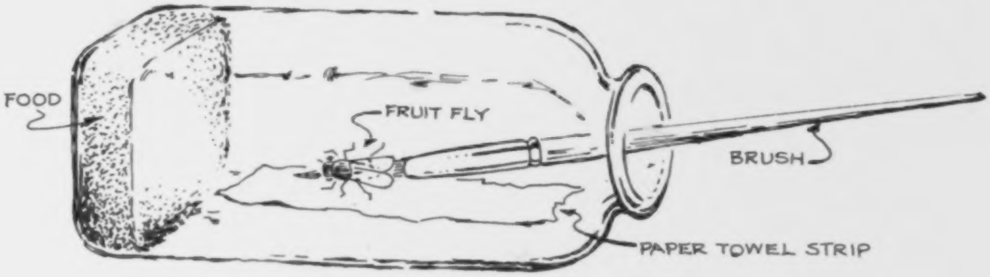
1. Caution: Fruit flies are easily injured. Always use the brush to move them around and to pick them up.

2. You must learn to tell male and female fies apart. One method is to count the number of stripes on the abdomen of a fly. The abdomen of the male (♂) has five stripes, which can be counted easily. The last stripe, which is at the tail of the fly, is wide and dark. On the female (♀) there are seven stripes on the abdomen and they are not as wide as the stripes on the male. As a check you may note that a female fly has a pointed tail and a male fly has a short,rounded tail.

3. With a hand lens observe the abdomens of your flies. Use the brush to separate male and female flies into two groups.

4. Cut a strip of paper towel about as long as your food bottle and about three centimeters wide.

5. Place the food bottle flat on the table and put the paper towel in the bottle as shown.



6. Using the brush, pick up a fly and place it on the paper towel in the bottle. Continue this until you have placed two females and two males in the bottle.

7. Place the stopper in the bottle and leave the bottle on its side until the flies become active again.

8. Place the remainder of the flies in a container that your teacher will give you.

9. On the bottle, place a label containing the following information:

Type of Fly
Date
Your Name

10. As soon as the flies are moving around, set the bottle upright in a spot assigned by your teacher.

INTERPRETATION

1. Why were the fruit flies anesthetized?

2. Why did you use a brush instead of tweezers for picking up the fruit flies?

1B-21

CRICKET CHIRPS

You have been investigating the world of insects for several weeks. You have been collecting data by observation and have used instruments to extend your senses and to make measurements. Up to this point your data have been simple. Now you need to learn how to organize data into a form from which you can draw some conclusions.

PROCEDURE

1. First, read the following paragraphs carefully:

   Several boys who live in a suburban community are enthusiastic insect collectors. One summer they collected many live crickets. They became interested in the chirping sounds of these insects and discovered that the sounds were made by rubbing the wings together. The boys decided to try to keep some crickets as pets from one summer to the next.

   One August night, having nothing better to do, they timed the chirps of their pets for 5 minutes. The average rate was 100 chirps per minute. Then they decided that watching television would be more interesting, so they stopped timing and went in to watch reruns. After a few nights of reruns they were back outside. One of the boys, John, said, "Hey, I think our crickets are chirping faster tonight. I think I'll time them again." He found the chirping rate to be 116 chirps per minute. This discovery raised a problem that the boys decided was more interesting than watching reruns on television: Why do crickets chirp at different rates on different nights?

   For the last two weeks in August the boys found that the chirping rate each night was slightly different. Although the rate varied, it decreased to 88 chirps per minute by the end of those two weeks. Fred thought that the chirping rate increased from a new moon phase to a full moon, then decreased from a full moon to another new moon. John, however, said that the decrease was due to the drop in temperature that had occurred over the two week period.

   Both boys timed the cricket chirps each night in the first two weeks of September. During this time the moon passed from a new moon phase to the full moon phase. Fred expected the chirping rate to increase as the moon changed. John expected the rate to continue decreasing because the night temperature had decreased even more since the last day of August. Again the rate fluctuated, but by the middle of September the

---

[1] Adapted from ERC Life Science, Variation, p. 61

rate was 64 chirps per minute. John was satisfied that he had found the cause of the decreasing rate. Fred was not convinced. He said, "If it's the temperature, then the rate of chirping should vary as the temperature changes." So, John rigged up a cardboard box with a covered light bulb as a source of heat. He found that by moving it closer to and farther away from a cricket he could increase and decrease the number of chirps.

During the next five nights the boys recorded the following data: Night 1: temperature 73°F., number of chirps 34; Night 2: temperature 81°F., number of chirps 42; Night 3: temperature 68°F., number of chirps 29; Night 4: temperature 84°F., number of chirps 45; Night 5: temperature 65°F., number of chirps 26.

2. Now you can begin to organize the data that the boys obtained. In the first column of the chart below, list the temperatures from the last paragraph of the story. In the second column list the number of chirps/minute for each temperature.

Night	Temperature	Chirps/Minute
1		
2		
3		
4		
5		

3. The data in the chart above are listed by the order of the nights. But this is of no real importance to the investigation—temperature and chirps/minute are the important data. In the chart on the next page, order the temperatures from the smallest to largest. Then, place the corresponding chirps per minute in the second column.

Temperature	Chirps/Minute

4. Look at the chart in Step 3. Do you think that the temperature and the chirps per minute are related? Explain your answer.

5. Do both temperature and chirps per minute change?

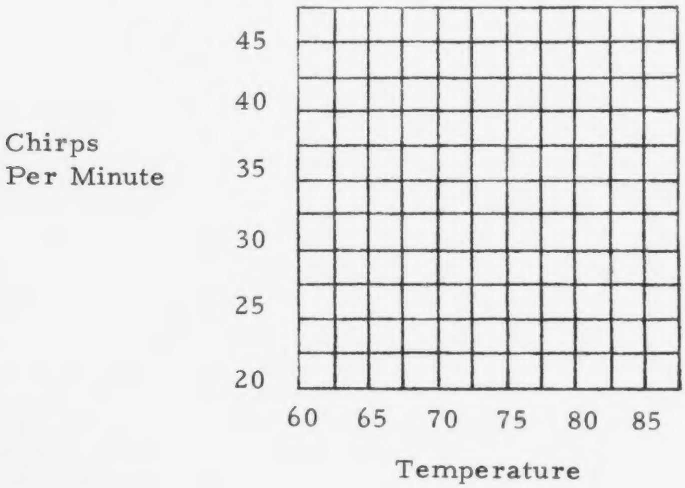
6. Quantities that change are variables. Do you think that the temperature depends on the number of chirps per minute or does the number of chirps per minute depend on the temperature? Explain your answer.

7. A variable that depends on another variable is called a dependent variable. The one that does not depend on another variable is called an independent variable. Which one of the variables (Items 5 and 6) is the independent variable?

   Which is the dependent variable?

8. Sometimes you can see on a graph things that are not easily seen on a table of data. On the next sheet is a grid to be used for making a graph of the data from the chart of Item 3. Always put the independent variable on the horizontal axis.

Plot the points on the grid below, as directed by your teacher.



INTERPRETATION

1. Describe how a change in temperature affects the number of chirps.

2. Use the graph to predict how many chirps you would expect if the temperature were:

   a. 90° ________________

   b. 60° ________________

   c. 40° ________________

3. State a rule that would allow other students to determine the temperature if they knew the number of chirps.

TIMING THE DEVELOPMENT OF FRUIT FLIES

If all went well your cultures of fruit flies should be developing. Have you seen any of the worm-like larvae yet? Perhaps some larvae have finished eating and are now in the resting stage called the pupa. Look on the paper strips or the sides of the culture bottles for the motionless pupae. From these the adult, winged flies will emerge (come out). A scientist once conducted an experiment to determine at what time of day the greatest number of adult fruit flies emerged from the pupa stage. You will use data from this experiment to construct a graph.

MATERIAL

straightedge
graph paper

PROCEDURE

1. In the experiment, cultures of flies were kept in a lightproof box. A light in the box was turned on from 9:00 A. M. to 9:00 P. M. When adults began to emerge from the pupae the scientist counted and removed the adults every hour for a twenty-four hour period.

   His data are shown on the following chart:

Time A. M.	Number of Flies	Time P. M.	Number of Flies
1:00	1	1:00	6
2:00	0	2:00	6
3:00	0	3:00	6
4:00	1	4:00	6
5:00	1	5:00	6
6:00	1	6:00	7
7:00	1	7:00	7
8:00	2	8:00	6
9:00	5	9:00	1
10:00	11	10:00	1
11:00	12	11:00	1
12:00	13	12:00	1

2. Plot the data on a grid. You must decide which variable is the independent one and which is the dependent one. Remember that the independent variable should be shown on the horizontal axis. Connect the plotted points with a line to form a line graph.

INTERPRETATIONS

1. At what hours did the fewest adults emerge from the pupa stage?

2. At what hour did the most flies emerge?

3. Does light affect the emergence of flies? Explain your answer.

4. Would you expect the same results if the culture were left in the light for twenty-four hours? Why or why not?

RELATED ACTIVITY

Using a culture of fruit flies and a light source,conduct a further investigation of this problem by varying the intervals of light and darkness. Prepare a table similar to the one you used in this investigation.

PICTURING DATA

According to an old saying, "A picture is worth 10,000 words." A graph is really a picture of data. The purpose of constructing a graph is to show important things about data quickly and clearly. This is especially true when a graph shows relationships between two different sets of data.

MATERIAL

graph paper

PROCEDURE

1. A scientist became interested in the relationship between the number of grasshoppers and the number of barn swallows. To get a picture of the relationship, if any, he counted both animals about twice a month during one summer. He counted the barn swallows that nested in an old shed and he counted the grasshoppers in 5 square meters of a meadow near the shed. Below is a chart of his data.

Date	Number of Grasshoppers	Number of Barn Swallows
April 15	0	0
May 1	24	0
May 15	30	0
June 1	30	19
June 15	28	22
July 1	22	24
July 15	20	22
August 1	17	24
August 15	13	24
September 1	10	24
September 15	11	24
October 1	10	0
October 15	10	0
November 1	6	0
November 15	0	0

2. Using the scientist's data, construct two line graphs on the same grid. Use a solid line to connect the points representing the grasshopper data and a dotted line to connect the points representing the swallow data.

INTERPRETATION

1. How do you account for the sudden appearance of grasshoppers?

2. How do you account for the sudden appearance of swallows?

3. How do you account for the sudden disappearance of grasshoppers?

4. How do you account for the sudden disappearance of swallows?

5. Do you think the swallows ate grasshoppers? Is there any evidence in the graph to support your answer? If so, what is it?

6. Write as many statements as you can based on the information pictured in the graph.

7. In what ways might a severe drought have affected the data?

RELATED ACTIVITY

Work Problem 8 on Page 706 of Biological Science: An Inquiry Into Life, Second Edition.

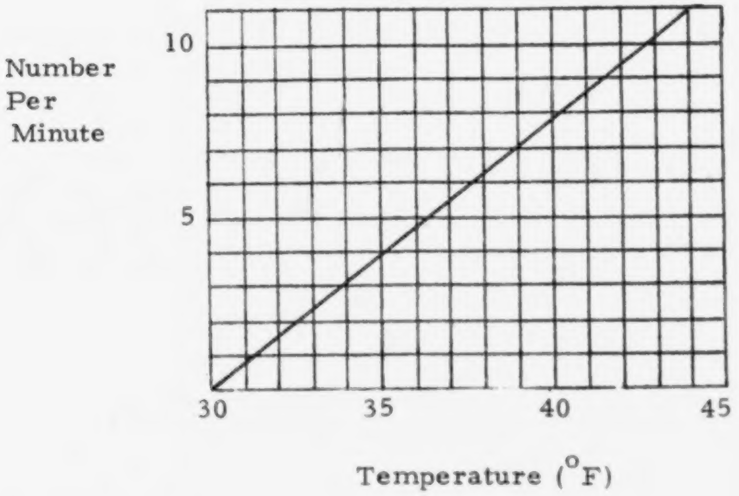
IDEAS FROM GRAPHS

Today you will study some charts and graphs containing data collected by scientists who study insects—entomologists. Careful study of such charts and graphs often allows scientists to draw conclusions that lead to further experimentation.

PROCEDURE

For each chart or graph below make a general statement that describes what the data tell you.

1. Breathing Rate of an Insect



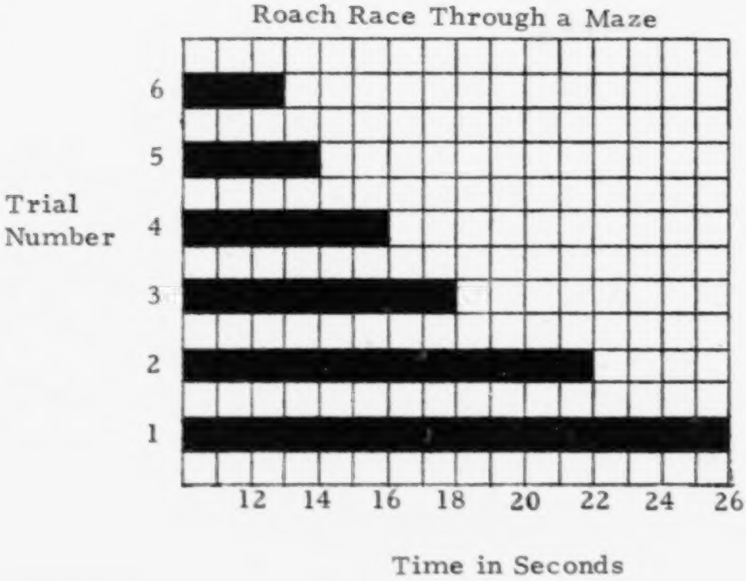
Conclusion:

2. Insect Egg Production

Insect	Eggs per Female
Grasshopper	300-600
Cockroach	200-1000
Housefly	75-200
Mosquito	100-1036
Wasp	50-75
Flea	50-400

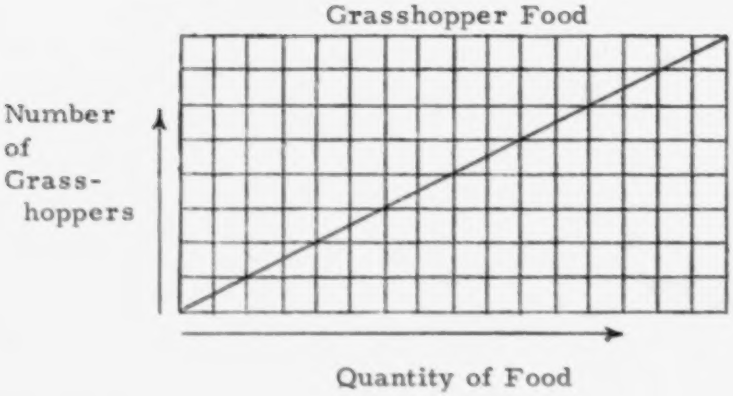
Conclusion:

3.



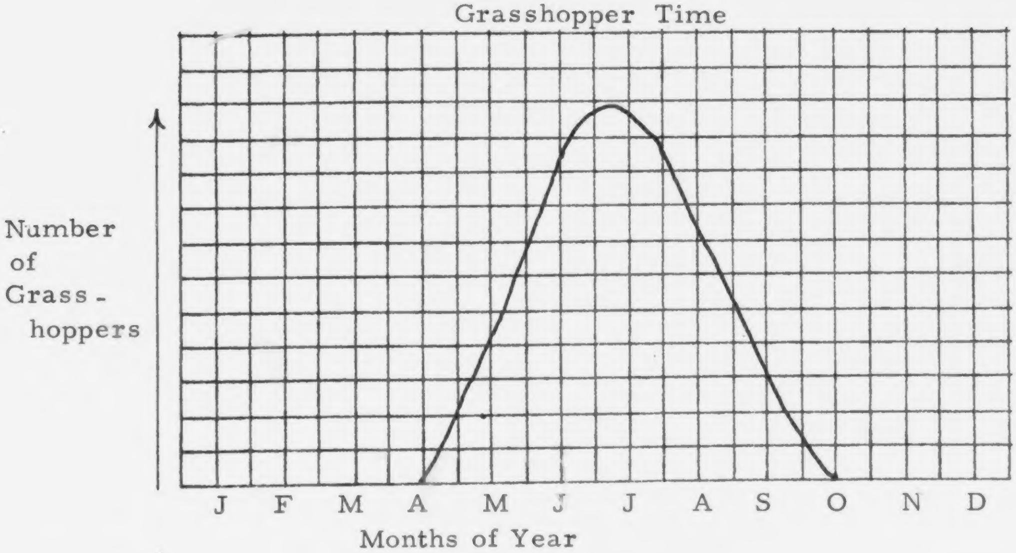
Conclusion:

4.



Conclusion:

5.



Conclusion:

6.

Measurements of Beetle Jaw Lengths
Made by Three Groups of Students

Beetles	Length of Jaw		
	Reported by Group I	Reported by Group II	Reported by Group III
A, ♂	1.1	1.5	1.1
B, ♂	0.9	1.0	1.1
C, ♂	1.5	1.4	1.3
D, ♀	0.6	0.7	0.6
E, ♀	0.4	0.5	0.3
F, ♀	0.7	0.6	0.5

Conclusion:

INTERPRETATION

Can more than one conclusion be made from a single graph or chart? If you answer, "Yes," then make a second statement for at least one of the graphs or charts. Indicate by number which chart or graph you used.

RELATED ACTIVITY

Select a graph or chart from a magazine or newspaper and write a statement explaining what it means to you.

1B-25

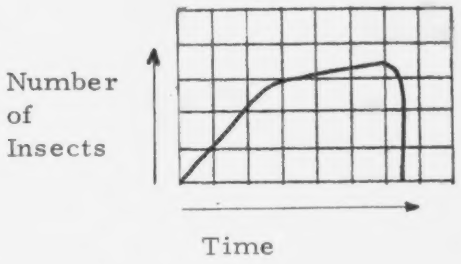
SUPPORTING IDEAS WITH DATA

You have written out ideas (conclusions) that you got from data expressed in the form of graphs. It is also important for a scientist to be able to recognize when a graph supports or fails to support an idea that he already has in mind. Today you have an opportunity to practice that skill.

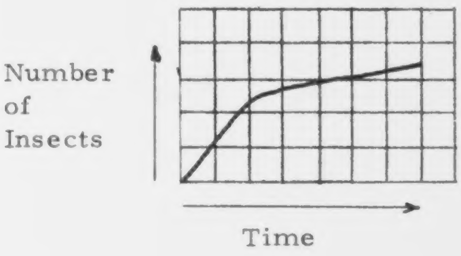
PROCEDURE

Graphs A, B, C, and D each express data collected by a group of entomologists. Following the graphs are several statements. Indicate by letter the graph or graphs (if any) that supports the statement. Then tell why you made your choice.

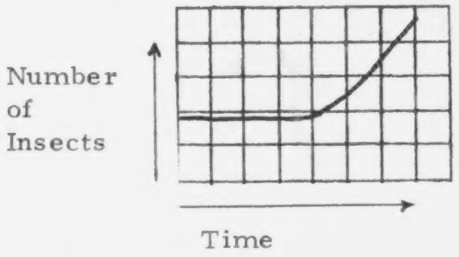
Graph A



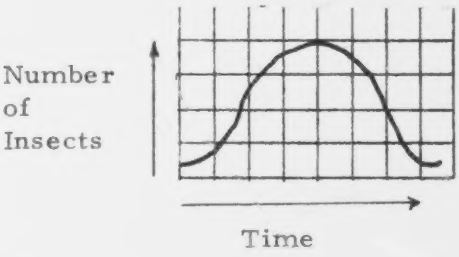
Graph C



Graph B



Graph D



1. The food supply for insects is limited.

   Graph chosen:

   Reason for choice:

2. An insecticide was used in the family garden.

Graph chosen:

Reason for choice

3. A new food supply was made available.

Graph chosen:

Reason for choice:

4. The insects have completed one generation.

Graph chosen:

Reason for choice:

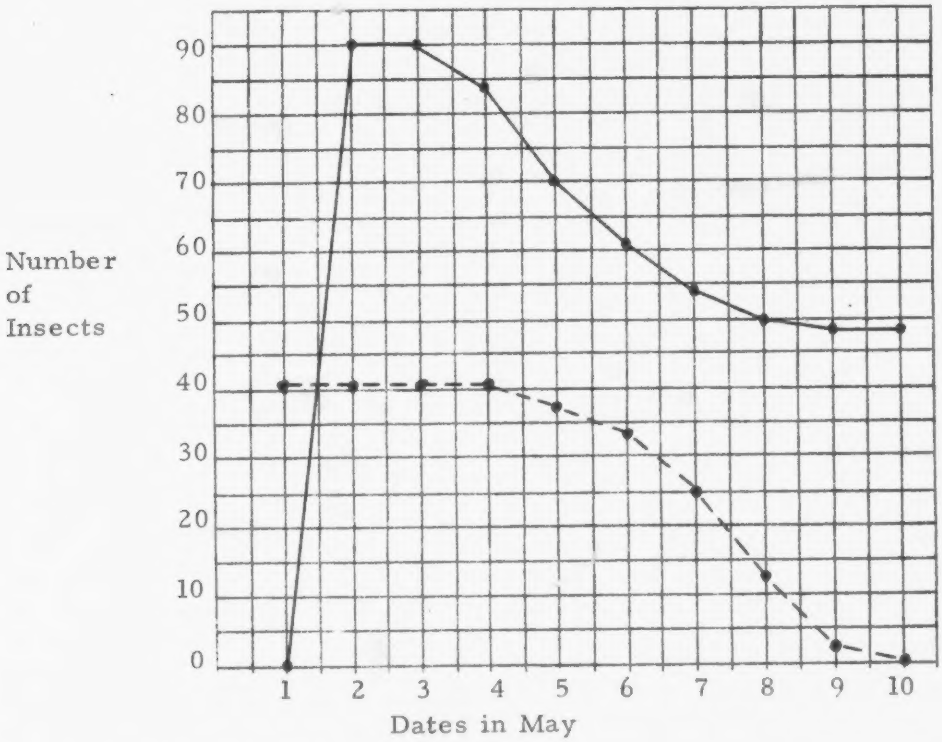
ARRANGE IN ORDER

From any set of data you may be able to draw more than one idea. This means that you are often faced with the problem of selecting the most reasonable ideas from a list of many possible ideas. You will now have an opportunity to practice this scientific skill.

PROCEDURE

1. Study the graph below. It shows data collected on a suburban lot.

Key: ______ grasshoppers
- - - - praying mantises



2. Read the three statements in Group I. On the basis of the graph, order the statements from most probable to least probable. Write Number 1 beside the most probable, Number 2 beside the next most probable, and Number 3 beside the least probable. Do the same for Group II.

Group I

_______ a. On May 2nd there were 90 grasshoppers counted in this area.

_______ b. Next year you will find no praying mantises on this lot.

_______ c. Praying mantises hatched before May.

Group II

_______ a. Praying mantises eat grasshoppers.

_______ b. From May 2 to May 10 there were more grasshoppers than praying mantises in the lot.

_______ c. You can only find praying mantises during the month of May.

INTERPRETATION

1. Why is it important that a scientist know how to order a set of ideas from the least to the most probable?

2. Distinguish between ordering by size or by time and ordering from the least to the most probable.

RELATED ACTIVITY

A farmer in Baltimore County observed that in a large area of his cornfield the cornstalks became weak and the plants fell over and died. You are asked to identify the insect that might be responsible for this situation. Use a copy of Insects by Zim and Cottam to find the "culprit." List in order of importance your reasons for selecting the insect.

COMBATING INSECT PESTS

Of the 750,000 known insects, the great majority have little or no effect on humans. Many are of great benefit. But about 1% of the known kinds of insects can be called pests. They destroy crops, carry disease and cause much irritation. Therefore, man attempts to control the numbers of these insects.

MATERIALS

Filmstrip, Combating Insect Pests

PROCEDURE

View the filmstrip Combating Insect Pests. From the filmstrip list as many ideas as you can that support the following statement:

> Man has learned many ways to control insects.

Do not include ideas that are not supported by the filmstrip.

INTERPRETATION

1. List several insects that are injurious to man and the kinds of injury they do.

2. If you were listing in order of importance the ways in which man attempts to control insects, which one would you list first? Which second?

3. Why is the control of insects of such economic importance to man?

4. How could you, as an individual, help to control mosquitoes?

RELATED ACTIVITY

Prepare a written report on any kind of insect that is a pest to man. Identify the insect, classify it, discuss its life cycle, and describe the habitat in which it lives. Determine the kind of harm it does and tell how man attempts to control it.

1B-28

THE COOL FRUIT FLY

Although insects are found all over the world, they are sensitive to temperature changes. But different kinds of insects have different amounts of sensitivity. Therefore, entomologists must investigate temperature sensitivity in each kind of insect. How would you go about designing an investigation of the temperature sensitivity of your fruit flies?

MATERIALS

- beaker, 250 ml
- fruit flies, 10
- hand lens
- cork stopper
- thermometer
- large test tube
- tin can
- ice
- dissecting needle
- stirring rod

PROCEDURE

1. Plan an investigation to test the following idea:

   Fruit flies become inactive when temperature is lowered.

   You may use any of the materials listed above.

2. Write out your plan and give it to your teacher.

3. After your plan has been checked, obtain the materials you need and carry out your plan.

4. Express your data in any form that you think desirable. Then write a statement of conclusions from your data.

RELATED ACTIVITY

Develop an idea that you think can be tested by an experiment. Construct a procedure to test the idea. Demonstrate the procedure.

Example of an idea:

A bessybug can pull five times its own weight.

INSECT CLASSIFICATION

Entomologists classify the kinds of insects into various groups. The insects in any one group all share several characteristics. Most of the characteristics used by entomologists for classification are structural characteristics. You have made a collection of insects and have learned many things about insect structure. You can now use this knowledge to develop a system of classification for the insects in your own collection.

MATERIALS

insect collection
hand lens

PROCEDURE

1. Examine your insects carefully.
2. Choose the characteristics that seem to you to be most useful for sorting your insects into groups.
3. Divide the bottom of your collection box into compartments to match the number of groups of insects in your classification system. Label each compartment with the characteristics of its group of insects.
4. Pin each insect in the compartment having the label that most closely corresponds to the insect's characteristics.
5. When you have completed the classification of your insect collection compare it with the classification systems used by other students in your class.

INTERPRETATION

1. Why is it important to have a classification system for insects?

2. What other scientists might use the classification system of entomologists?

3. What characteristics seem to be most important in classifying insects?

4. If live insects were available for classifying, what other characteristics might have been used for classification?

RELATED ACTIVITY

Read Pages 55-59 in Exploring Life Science by Thurber and Kilburn. This explains the system of classification usually used by entomologists. How does your system compare with this one?

OBJECTIVES

Insects

1. Identify the appropriate sense needed to make an observation.
2. Distinguish between an observation and a non-observation.
3. Name the qualitative characteristics of objects, using one or more of the senses.
4. Demonstrate the ability to locate, collect, and preserve insects.
5. Demonstrate the use of a hand lens.
6. Identify and describe the functions of the main parts of a microscope.
7. Demonstrate the proper use, care, and handling of a microscope.
8. Identify and describe the functions of the main parts of a stereomicroscope.
9. Demonstrate the proper use, care, and handling of a stereomicroscope.
10. Demonstrate a procedure for measuring length.
11. Demonstrate a procedure for measuring time.
12. Demonstrate the ability to read a thermometer.
13. Demonstrate the ability to find an average.
14. Demonstrate the ability to select and use an appropriate instrument to extend observations.
15. Demonstrate a procedure for measuring volume.
16. Demonstrate a procedure for measuring mass.
17. Demonstrate a procedure for culturing fruit flies.
18. Construct a chart of paired measurements.
19. Construct a chart of paired measurements after first ordering one of the sets of measurements.
20. Distinguish the dependent variable from the independent variable, given a chart of paired measurements with one of the sets of data ordered.
21. Construct a line graph from a table of data.
22. Construct one or more ideas from a set of observations.
23. Construct one or more ideas from a table or graph.
24. Identify the data that supports an idea.
25. Order a list of ideas from least to most probable.
26. Distinguish whether or not an idea is supported.
27. Construct an investigation and demonstrate the procedures to test an idea.

NOTES

NOTES

NOTES

NOTES

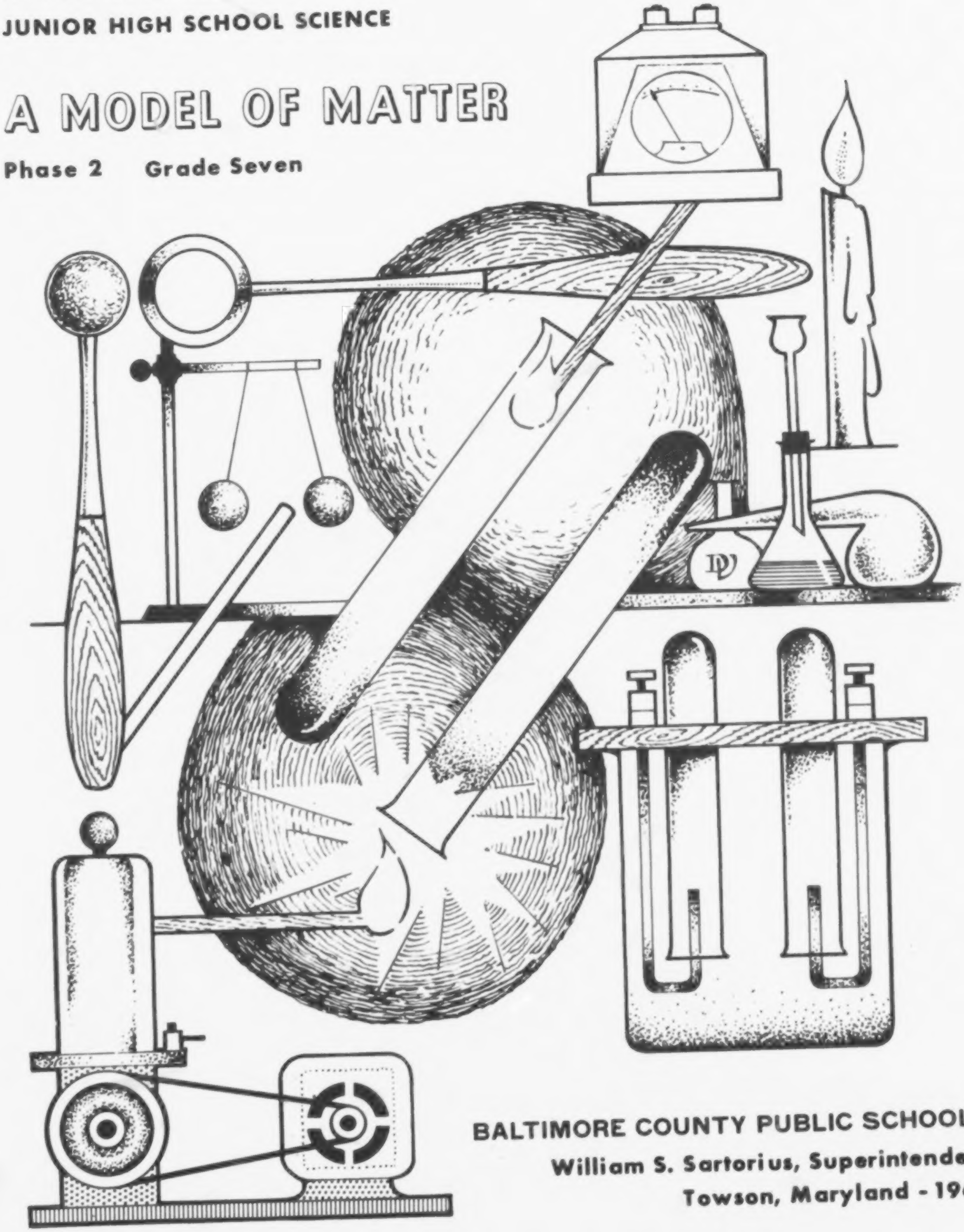
NOTES

A SEARCH FOR STRUCTURE

A STUDENT MANUAL FOR
JUNIOR HIGH SCHOOL SCIENCE

A MODEL OF MATTER

Phase 2 Grade Seven



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SEPARATING A MIXTURE

In Phase One you learned to make observations, to draw inferences from these observations, and to classify things you observe. You will need to use these skills as you continue your search for structure in the world around you.

Today you are going to investigate a sample of matter that is a mixture of different substances. How can the substances in the mixture be separated?

MATERIALS

Sample #2 in plastic vial

PROCEDURE

1. Carefully pour the contents of the vial on a sheet of notebook paper. Examine the mixture, using your senses of sight and touch.

2. Develop a method for separating the substances found in the vial. In the chart below list the procedures you plan to use and the equipment you will need.

Suggested Procedures	Equipment Needed

3. When your plan for separating the substances has been approved by your teacher, obtain equipment and carry out the investigation. Summarize your procedures and your results in the chart below.

Procedures Used	Description of the Substance

4. Compare the procedures you used with the list of "best" procedures developed by the class. Add to your list any procedures that you may have overlooked but now feel are appropriate. Explain how each could be used in separating your mixture.

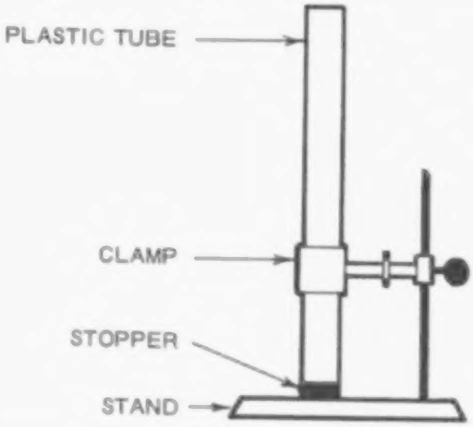
2-2

SEPARATING SUBSTANCES BY SEDIMENTATION

You have found that you can separate substances by sorting the particles in a mixture according to their sizes. But hand sorting is a slow and tedious job. There is a better way to order particles by size.

MATERIALS

plastic column with stopper
  at bottom
ring stand and clamp
sorted samples, 5
watch with second hand
water



PROCEDURE

1. You have been given 5 sorted samples. Arrange them in order of particle size from smallest to largest, numbering the samples from 1 to 5.

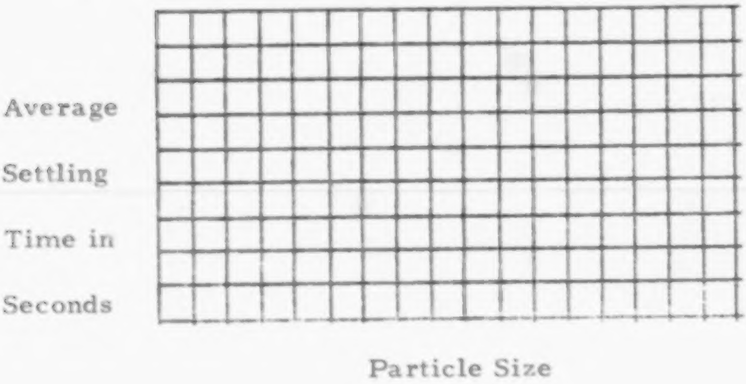
2. Fill the plastic column with water to within 6 cm of the top. Drop half of the sample with Particle Size 1 into the column. Start timing the instant the grains hit the water; stop when the first grains get to the bottom of the column. This is the settling time. On the chart below record the time in the column "Time of First Trial." Do not remove the particles from the column. Drop the second half of Sample #1 into the column. On the chart record the settling time in the column "Time of Second Trial."

3. Repeat Item 2 with Samples 2, 3, 4, and 5. It is not necessary to clean or empty the tube between samples.

4. Compute the average settling time for each particle size by adding the time of the first trial to the time of the second trial and dividing by two.

Particle Size	Time of First Trial	Time of Second Trial	Average Time
#1			
#2			
#3			
#4			
#5			

5. Graph your data from the preceding chart.



INTERPRETATION

1. Particles of which size fell most rapidly? Which size fell most slowly?

2. From the results of your investigation, make a tentative general statement concerning particle size and settling time.

3. Suppose that all the particles were dropped into the column at the same time. Make a sketch of the probable arrangement of the particles after they came to rest.

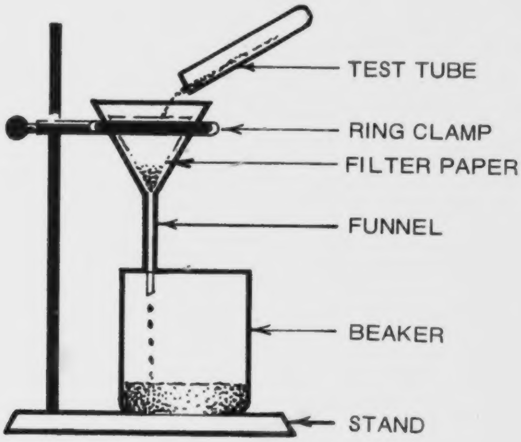
2-3

SEPARATING SUBSTANCES BY FILTRATION

Mixtures of similar substances cannot always be separated by examination or even by sedimentation. If a mixture consists of particles that are very much alike in size and weight, separation may be difficult. Sometimes, however, particles in such mixtures may be separated by filtration.

MATERIALS

- test tube containing sand
- test tube containing sugar
- test tube containing calcium carbonate
- watch glass
- funnel
- ring stand
- ring clamp
- filter paper
- beaker
- rubber stopper



PROCEDURE

1. Examine the sand. List your observations below.

2. Add water to the test tube containing sand. Cover the test tube and shake it. Pour the mixture of sand and water into a funnel lined with filter paper. Remove the filter paper, unfold it, and lay it on a watch glass. Examine the residue (the solid on the filter paper). Then examine the filtrate (liquid) in the beaker. List your observations in the chart in Item 4.

3. Look at the sugar. List your observations below.

4. Repeat Item 2, using sugar in place of the sand.

	Residue	Filtrate
Sand		
Sugar		

5. Look at the calcium carbonate powder. List your observations.

6. Using the calcium carbonate powder, repeat Item 2. Pour 5-10 drops of the filtrate in a watch glass. Examine and record your observations below.

7. Allow the liquid in the watch glass to stand overnight. Observe it carefully the next day and list your observations.

INTERPRETATION

1. What happens when a sand and water mixture is filtered?

2. What happens when a sugar and water mixture is filtered?

3. What happens when a calcium carbonate and water mixture is filtered?

4. Does a clear filtrate indicate the removal of all undissolved materials? Explain your answer.

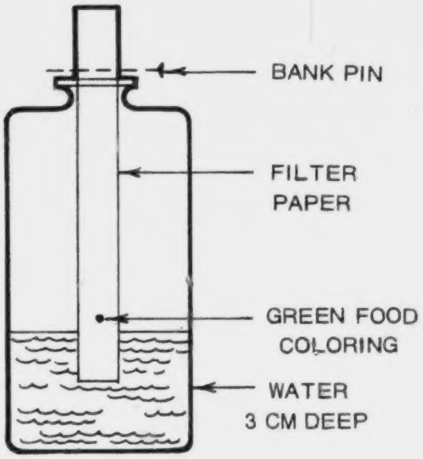
5. How could you separate a mixture of sand and sugar?

SEPARATING SUBSTANCES BY CHROMATOGRAPHY

You have discovered that some particles of matter are small enough to pass through filter paper. If you were to filter water colored with green food coloring you would see that most of the green color would pass through the filter paper. In this investigation you will separate the small particles that make up green food coloring.

MATERIALS

- chromatography paper with green spot, 15 cm
- bank pin
- wide-mouth bottle, 8 oz



PROCEDURE

1. Pour water into the bottle to a depth of about 3 cm.

2. Hold the chromatography paper against the outside of the bottle so that the bottom of the paper is about 1 cm below the level of the water. Mark the top of the chromatography paper at the top of the bottle. Push the pin through the center of the chromatography paper at the mark.

3. Carefully lower the chromatography paper into the bottle until the pin rests on the top of the bottle. THE GREEN DOT MUST NOT TOUCH THE WATER.

4. Allow the water to go up the chromatography paper until it reaches the pin. When the water reaches the pin, remove the paper and empty the water from the jar. Put the paper back into the bottle to dry. DO NOT TOUCH THE CHROMATOGRAPHY PAPER.

5. Observe the chromatography paper as it dries. List all of your observations.

INTERPRETATION

1. How did the water affect the green color?

2. How many different colors are present in this green food coloring? Explain your answer.

RELATED ACTIVITY

At home try to separate at least two substances other than green food coloring; for example, vinegar, colored detergent, Worchestershire sauce, or any other colored liquid you can find. You may wish to use some liquid other than water as the solvent. Either a paper towel or filter paper will serve for chromatography paper. Try different kinds of paper. In place of the bank pin you can use a heavy piece of wire or a small nail. Write up your activity, listing the materials used and the results. Bring the dried papers to class.

2-5

A DESCRIPTION OF MATTER

The preceding four investigations have yielded data that should enable you to describe some of the characteristics of matter. Now you will have an opportunity to interpret this data.

PROCEDURE

The investigations that have given you information about the nature of matter are listed below. Eight statements about the nature of matter are also listed. In the blank in front of each statement place the letters that indicate the appropriate investigations. More than one investigation may apply to some of the statements.

Investigations

A. Separating Mixtures

B. Separating Substances by Sedimentation

C. Separating Substances by Filtration

D. Separating Substances by Chromatography

E. None of the Investigations

Statements

______ 1. Matter can be broken into smaller parts.

______ 2. Particles of matter vary in size.

______ 3. Some particles of matter can be separated by color.

______ 4. Insoluble particles of matter can be separated from soluble particles by filtration.

______ 5. Some particles of matter can be separated by magnetism.

______ 6. Some particles settle in a liquid more rapidly than others.

______ 7. Mixtures are made of particles.

______ 8. All matter is made of particles.

INTERPRETATION

1. Which of the preceding statements relates to only one investigation? Does this indicate that one investigation is more important than the others? Explain your answer.

2. Which of the above statements are supported by all four investigations? Explain your response.

MAKING SCIENTIFIC MODELS

In many cases it is impossible to observe objects or events directly. When scientists cannot study a group of objects or events (a system) directly or when a system is very complex they make a model of the system. You can do this too.

MATERIALS

unknown system
parts to duplicate unknown system

PROCEDURE

1. Using as many of your senses as possible, examine the unknown system without opening or destroying it. Describe the characteristics of the system.

2. Using the materials given to you, construct a model that has as many of the characteristics of the unknown system as possible.

3. List the materials that you used in your model.

INTERPRETATION

1. Which characteristics of your model system are similar to those observed in the unknown system?

2. Suggest a situation in which scientists have used a model when they have been unable to study a system directly.

BUILDING A MODEL OF THE STRUCTURE OF MATTER

Thus far your observations of matter have been limited. You have observed characteristics by which particles may be separated. But in order to understand the structure of matter, you will need to make observations of how matter behaves.

The next group of investigations, 2-7 to 2-19, deals with the behavior of matter under different conditions. While working on the investigations you will not be expected to try to explain what you observe. Once your observations are completed, however, you will perform the second step that a scientist follows in his work; namely, grouping observations to show similarities and differences. By doing this you may discover some ideas about the structure of matter. These ideas--hypotheses--should be made for each group of investigations.

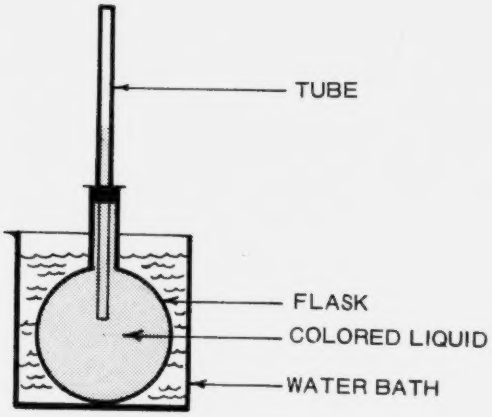
The final task will be to look at the hypotheses and attempt to construct a general explanation that will account for all of the hypotheses you have proposed. This general explanation will be a model for the structure of matter.

2-7

HEATING AND COOLING A LIQUID

MATERIALS

large containers for water baths, 2
colored liquid
small flask
one-hole stopper fitted with
    40 cm glass tube
ice
wax pencil



PROCEDURE

1. Completely fill a small flask with colored liquid. Insert the stopper and tubing as shown in the diagram. Use a wax pencil to mark the level of liquid in the tube.

2. Place the flask in a container of hot water. After two minutes observe the level of colored liquid in the glass tube. Record your observations.

3. Put the flask in a container of ice water. After two minutes observe the level of colored liquid in the glass tube. Record your observations.

INTERPRETATION

1. What happened to the level of liquid in the tube as the flask was heated?

2. What happened to the level of liquid in the tube as the flask was cooled?

3. What happened to the volume of the liquid as the liquid was heated?

4. What happened to the volume of the liquid as the liquid was cooled?

DYE AND WATER

MATERIALS

large glass container	eyedropper
methylene blue dye	paper towel
timing device	

PROCEDURE

1. Pour water into the large glass container until it is about three-quarters full.
2. Allow the water in the large glass container to stand for a few minutes until the water is still.
3. Without disturbing the water, quickly and carefully add three drops of the dye near one edge of the container.
4. Observe how the dye behaves at two-minute intervals for ten minutes. Record your observations in the data chart.

Time (minutes)	Observations
Start	
2	
4	
6	
8	
10	

INTERPRETATION

Describe how the contents of the container changed during the investigation.

2-9

PAPER TOWEL IN WATER

MATERIALS

small beaker
strip of paper towel
water

PROCEDURE

1. Cover the bottom of the beaker with tap water.
2. Gently lower the tip of the paper towel into the middle of the water surface. Hold the paper towel as still as you can.
3. Observe the paper towel for two minutes. Record your observations.

2-10

BALL AND RING

MATERIALS

ball and ring apparatus
heat source
beaker of water
asbestos pad
goggles

PROCEDURE

1. Try to pass the ball through the ring at room temperature. Record your results in the chart below.

2. Heat the ball for three minutes. Try to pass the ball through the ring. Record your results in the chart below.

3. Cool the ball in the beaker of water and then heat the ring for three minutes. Try to pass the ball through the ring. Record your results.

4. Heat both the ball and the ring for three minutes and try to pass the ball through the ring. Record your results.

Trial	Results
1. Ball and ring at room temperature	
2. Heated ball	
3. Heated ring	
4. Heated ball and ring	

INTERPRETATION

What do you think may have happened to the sizes of the ball and ring in each trial? Record your conclusions in the chart below.

Trial	Changes You Think Occurred
1	
2	
3	
4	

GLASS SLIDES AND WATER

MATERIALS

glass slides, 2
beaker containing water

PROCEDURE

1. Press one clean, dry glass slide upon another clean, dry glass slide. Try to separate the two slides without sliding them. Record your observations.

2. Place the two glass slides, one at a time, in the beaker of water. Remove them. Without drying them, press one upon the other as you did in Procedure 1. Again try to separate the glass slides without sliding them. Record your observations.

INTERPRETATION

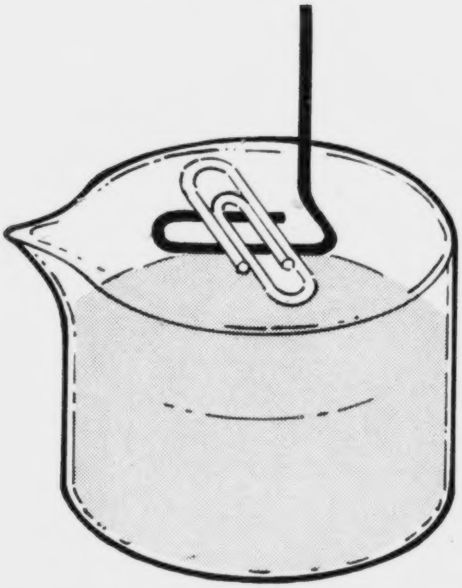
Under which of the two conditions were the glass slides more difficult to separate?

2-12

A PAPER CLIP AND WATER

MATERIALS

beaker
paper clips, 2



PROCEDURE

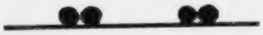
1. Bend one paper clip as shown in the diagram.

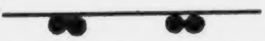
2. Lower the other paper clip gently onto the surface of the water as shown in the diagram. If the paper clip does not remain on the surface in the first trial, repeat the procedure until you are successful.

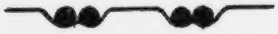
3. Observe the paper clip and the water surface very carefully. Describe the water surface around the paper clip.

26

4. Circle the letter of the diagram that most closely resembles a cross-sectional view of the paper clip and the water surface.

a.


b.


c.


2-13

THE UNKNOWN IN A BAG

MATERIALS

paper bag with unknown object

PROCEDURE

Without damaging the bag or looking into it, observe the object within it. Record your procedure and observations.

INTERPRETATION

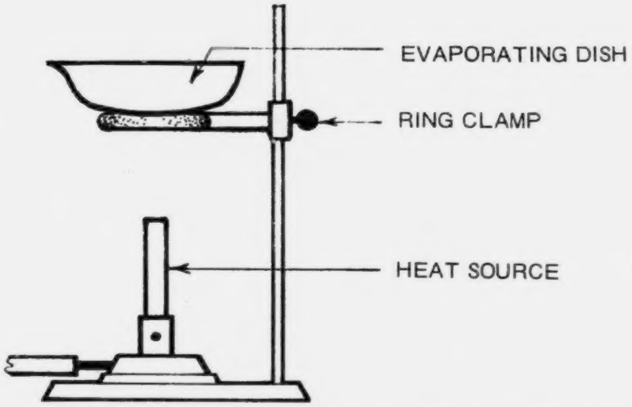
If you had to identify the object in the bag which of its properties would be most useful?

2-14

ICE CUBES

MATERIALS

- ice cube
- evaporating dish
- ring stand
- ring clamp
- goggles
- wire gauze pad
- heat source



PROCEDURE

1. Observe an ice cube in an evaporating dish for approximately 30 seconds. Record your observations.

2. Set up the apparatus as shown in the diagram above. Place the evaporating dish on a ring stand and heat until the contents of the dish have disappeared. Record everything that takes place during the heating of the dish.

2-15

SWIRLING SMOKE

MATERIALS

hydrochloric acid, concentrated
ammonium hydroxide, concentrated
test tube, 15 mm x 150 mm
eyedroppers, 2
beakers, 400 ml, 2
glass plates, 2

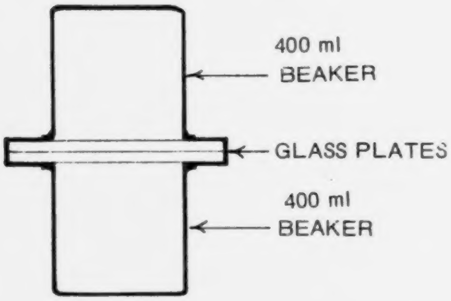
PROCEDURE

1. Observe carefully as your teacher uses an eyedropper to place just one drop of concentrated acid in a test tube and then with a second eyedropper, cautiously adds one drop of ammonium hydroxide to the acid. Record what takes place.

2. Observe carefully and record your observations as your teacher does the following:

Pour about 5-10 ml of concentrated hydrochloric acid into a 400 ml beaker. Swirl the acid around to wet the walls of the beaker and then pour the excess off. Immediately cover the beaker with a glass plate.

Repeat the procedure in another beaker, using concentrated ammonium hydroxide. Arrange the beakers as shown in the diagram. Hold the top beaker in position and quickly remove the glass plates.



INTERPRETATION

1. What evidence indicated that a change occurred in the test tube?

2. What evidence indicated that a change took place in the beakers?

3. In what way are the two demonstrations similar?

4. In what way are the two demonstrations different?

2-16

OBSERVING FILTER PAPER

MATERIALS

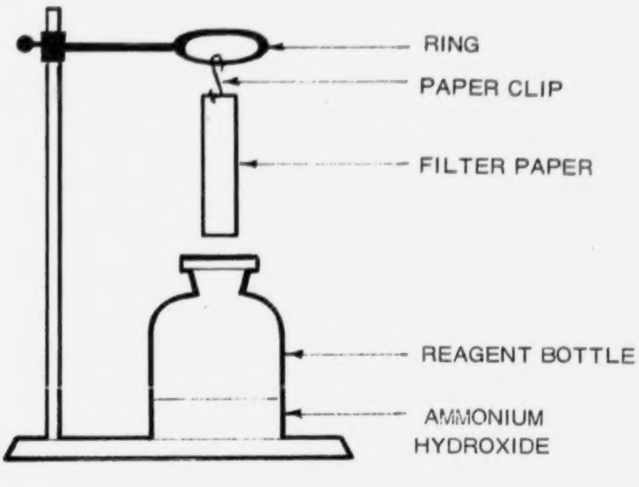
- filter paper
- phenolphthalein solution
- eyedropper
- forceps
- paper clip
- goggles
- ammonium hydroxide
- reagent bottle

PROCEDURE

1. Using forceps, dip a piece of filter paper into phenolphthalein solution.

2. Using an eyedropper, add a drop or two of ammonium hydroxide to the filter paper. Record your observations.

3. Dip another piece of filter paper into phenolphthalein solution. In a place where there are no air currents, set up the apparatus as shown in the diagram.


RING
PAPER CLIP
FILTER PAPER
REAGENT BOTTLE
AMMONIUM HYDROXIDE

4. Open the bottle of ammonium hydroxide and observe the set-up until you see a change in the filter paper. Record your observations.

INTERPRETATION

Did the two substances, ammonium hydroxide and phenolphthalein, come in contact when the filter paper was placed above the ammonium hydroxide? What evidence do you have to support your answer?

ALCOHOL AND WATER

MATERIALS

graduated cylinder, 100 ml, 2
methyl alcohol
eyedropper

PROCEDURE

1. Carefully pour 25 ml of water into one of the graduated cylinders. To increase the accuracy of your volume measurement, use the eyedropper as directed by your teacher.

2. In the other graduated cylinder, pour 25 ml of water. Again use the eyedropper to measure exactly.

3. Pour the measured 25 ml of water from one graduated cylinder into the other cylinder containing 25 ml of water.

4. In the chart below record the total volume of the mixture.

5. Repeat Items 1 through 4, using 25 ml of alcohol in one cylinder and 25 ml of alcohol in the other cylinder.

6. Repeat Items 1 through 4, using 25 ml of alcohol in one cylinder and 25 ml of water in the other cylinder.

Quantities before Mixing	Total Volume after Mixing
25 ml of water mixed with 25 ml of water	
25 ml of alcohol mixed with 25 ml of alcohol	
25 ml of water mixed with 25 ml of alcohol	

INTERPRETATION

1. Which, if any, of the three trials gave a result that is different from what you expected?

2. If you got any unexpected results, explain how they differed from what you expected.

A SET OF GLASS TUBES

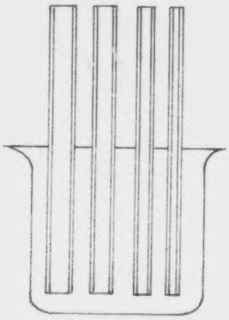
MATERIALS

beaker
water
set of glass tubes
mercury
metric ruler

PROCEDURE

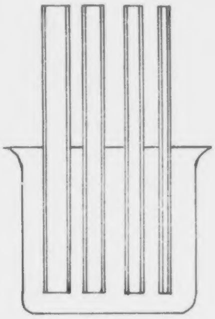
1. In a stand or some other container, arrange a set of glass tubes according to the size of the bore--the tube with the largest to the left and the tube with the smallest bore to the right.

2. Pour mercury into the bottom of the stand or container. Record on the drawing below the height of the mercury in the container and in each tube. Carefully show the shape of the surfaces of the mercury in each tube.



Mercury

3. Carefully empty the equipment. Repeat Items 1 and 2, using water in place of mercury. On the drawing below record your observations as you did for Item 2.



Water

INTERPRETATION

1. In what ways did the mercury and water behave alike?

2. In what ways did the mercury and water behave differently?

3. How do the heights of the water in the tubes vary with the sizes of the bores?

4. How do the heights of the mercury in the tubes vary with the sizes of the bores?

2-19

AN UNUSUAL BALLOON

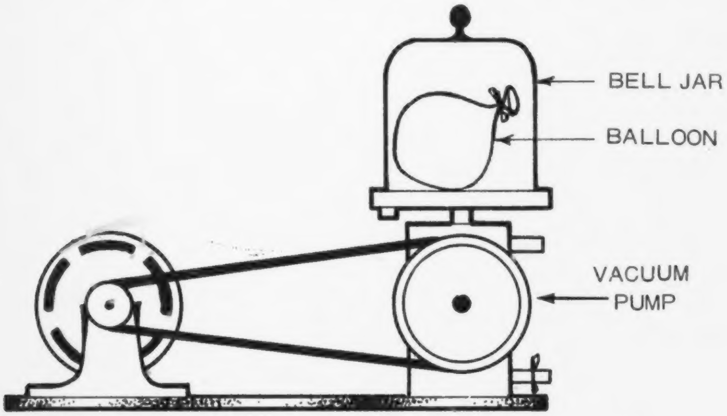
MATERIALS

vacuum pump
bell jar
sealing compound
rubber balloon

PROCEDURE

1. Partially fill a balloon with air until it has a diameter of about 6 cm. Tie a knot in the balloon to prevent the air from escaping.

2. Place the partially filled balloon on the platform of the vacuum pump. Do not let the balloon block the opening on the platform. Place a bell jar over the balloon as shown in the diagram.



3. Apply sealing compound to the bottom of the bell jar to insure an airtight seal between the jar and the platform.

4. Turn on the pump for 20 to 30 seconds. When the pump is turned off, close the valve to prevent air from entering the bell. Record what happens to the balloon.

5. Open the valve and allow air to re-enter the bell jar. Record what takes place.

INTERPRETATION

1. Explain what you think caused the change you observed in the balloon in Item 4 of the Procedure.

2. Explain what you think caused the change you observed in Item 5 of the Procedure.

2-20

CLASSIFYING OBSERVATIONS OF MATTER

In Investigations 2-7 to 2-19 you have observed how matter behaves under various conditions. You have seen at least 4 or 5 different kinds of behavior. Try to classify the investigations so that those in any one group show a similar kind of behavior. If you wish, you may add groups on the back of the page.

Group 1

Group 2

Group 3

Group 4

FROM MANY TO ONE

You have attempted to classify the observations of matter that you have made during the past several weeks. You will now try to explain why the matter behaved as it did. This may prove to be a time-consuming and difficult task, but it is necessary if you are to develop a satisfactory model of the structure of matter.

PROCEDURE

1. Look at each of your groups of investigations. For each group construct a written hypothesis that might explain the behavior shown by matter in the investigations of that group.

2. Exchange the set of hypotheses developed by your laboratory team for those developed by another team. Examine each hypothesis to determine whether it satisfactorily explains what it was intended to explain. Change any hypothesis that does not seem satisfactory to you.

3. Re-exchange the sets of hypotheses. Examine the criticisms that the other team made of your hypotheses. Decide whether to accept or reject the criticisms.

INTERPRETATION

1. List the hypotheses accepted by the class. For each hypothesis record the investigation or investigations that give evidence to support it.

2. List any investigation that is not explained by the hypotheses accepted by the class.

2-22

EXTENDING THE MODEL OF MATTER

You have just completed a series of investigations in which you observed how matter behaves. Your observations enabled you to come to some tentative conclusions about the structure of matter. For example, you probably decided that matter is made of very small particles. These particles can be called molecules. A molecule is the smallest particle of a substance that you can have and still have that substance. From this point on we will use the term molecule when referring to such particles.

There is an important question that has not yet been answered. What is the structure of the molecules that make up matter? In the next series of investigations (2-23 to 2-27) you will make some additional observations of how matter behaves. These observations should help you to arrive at some conclusions about the nature and structure of the molecules of matter.

Some of these investigations will be demonstrated by the teacher and some you will carry out yourself. As you observe, keep a record of the changes in matter by completing the chart on the next page. You will use this chart as a basis for constructing your own ideas about the structure of molecules.

SUMMARY OF 2-23 TO 27

Name of Investigation	Initial Substances	Final Substances
2-23		
2-24		
2-25		
2-26		
2-27		

2-23

HEATING AN ORANGE-RED POWDER

PROCEDURE

1. Observe carefully as your teacher performs this investigation. Diagram the arrangement of the equipment.

2. What happened in the test tubes filled with water?

3. When the test tube containing the orange-red powder was heated, what happened in it?

4. Fill in the chart found in 2-22 .

INTERPRETATION

1. What evidence do you have that a change took place during this investigation?

2. Give an explanation for the way the water acted.

3. Give an explanation for the way the orange-red powder acted when it was heated.

4. Explain the change in appearance of the upper portion of the tube that contained the orange-red powder.

5. Explain the difference in behavior of the glowing splint when placed in the first and then in the second test tube.

6. Explain the difference in behavior of the glowing splint when placed in the third and then the fourth test tube.

7. Explain the behavior of the orange-red powder 10 minutes after the heating was stopped.

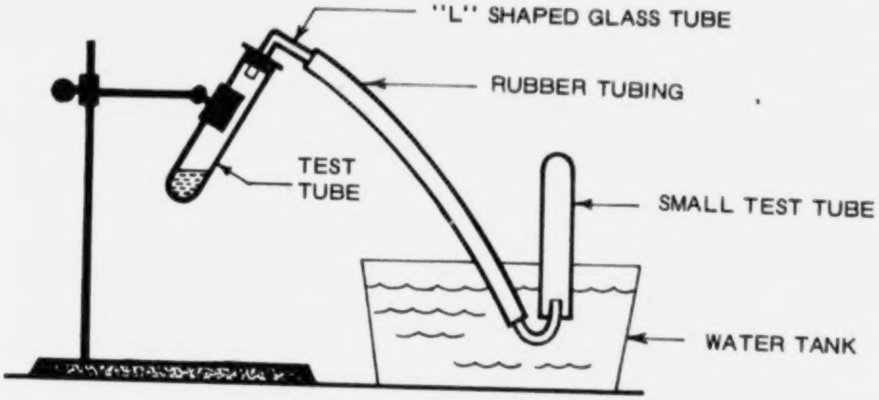
8. Suggest how the particle theory might explain the changes you have observed in this investigation.

2-24

LIQUID X AND ZINC

MATERIALS

- Liquid X
- mossy zinc
- rubber tubing
- test tubes, 18 x 150 mm, 3
- test tube, 25 x 200 mm
- rubber stopper, #4, one-hole
- goggles
- rubber stopper, #1, solid, 3
- glass bend
- water tank
- balance
- wood splints, 2



PROCEDURE

1. Measure approximately 5 grams of mossy zinc.

2. CAUTION: GOGGLES MUST BE WORN FROM THIS POINT UNTIL COMPLETION OF THE INVESTIGATION.

3. Set up the apparatus as shown in the diagram. CAUTION: HANDLE LIQUID X CAREFULLY.

4. Carefully remove from the large test tube the rubber stopper containing the glass bend.

5. Carefully slide (do not drop!) the zinc into the large test tube of Liquid X. Quickly insert the stopper with the glass bend.

6. Observe the action in the large test tube. Record your observations below.

7. Invert a small tube filled with water over the rubber tube in the water tray as shown in diagram.

8. Observe the action in the small inverted test tube and record your observations below.

9. After all of the water has been forced from the inverted test tube, carefully remove the rubber tubing. While the mouth of the test tube is still under water place a stopper in it. Place this stoppered test tube on the table but keep it separated from the other test tubes.

10. Repeat Items 7 and 9 using two additional test tubes.

11. Remove the stopper with the glass bend and rubber tubing from the large test tube. Pour the contents into a container provided by the teacher. Rinse the large test tube thoroughly with water and return it to the place designated by your teacher.

12. Do not use the first tube of gas that you collected.

13. Hold the second stoppered test tube in an upright position and remove the stopper. Wait for approximately one minute. Then have your laboratory partner place a burning splint to the mouth of the test tube. Record your observations.

14. Steadily hold the third stoppered test tube in an inverted (upside down) position and remove the stopper. Wait for approximately one minute and have your laboratory partner place a burning splint at the mouth of the test tube. Record your observations.

15. Fill in the chart found in 2-22.

INTERPRETATION

1. Explain what happened when Liquid X and zinc were placed together in the large test tube.

2. Explain what happened to the water in the small test tube. Give a possible reason for this behavior.

3. Was the substance in the small test tube heavier or lighter than air? What evidence do you have to support your answer?

4. Describe the differences between the substances you started with and those you ended with.

2-25

ELECTROLYSIS

Can a liquid be separated into smaller particles? We can find out by using the procedure called electrolysis. When you have completed this investigation you should be able to define the word, electrolysis.

PROCEDURE

Observe carefully as your teacher carries out the procedure.

1. Observe the wires in the test tubes. List your observations.

2. Observe the tops of the test tubes. List your observations.

3. Do the levels of Liquid Y in the test tubes change? If so, what occupies the spaces above the levels of the liquid?

4. Is there any difference in the levels of liquids in the two test tubes? Explain your answer.

5. What did you observe when the splints were placed at the mouths of the test tubes?

6. Fill in the chart found in 2-22.

INTERPRETATION

1. Where do you think the gases collected in the test tubes came from?

2. Can Liquid Y be broken into smaller particles? Explain your answer.

2-26

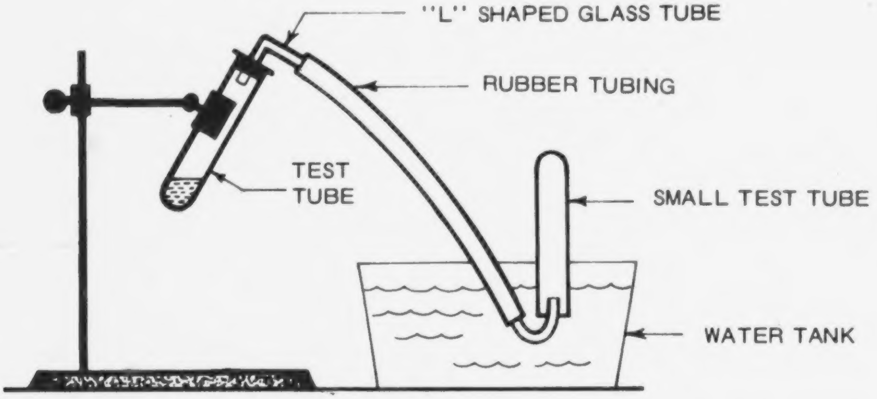
BUBBLING WATERS

MATERIALS

- Liquid Z
- test tube, 25 x 200 mm
- test tubes, 18 x 150 mm, 4
- rubber stopper, #4, one-hole
- glass tube, L-shaped
- rubber tubing
- goggles
- rubber stoppers, #1, solid, 4
- water tank
- wooden splints
- ring stand
- burette clamp
- graduated cylinder, 100 ml
- black powder

PROCEDURE

1. Arrange your apparatus as indicated in the diagram below.


"L" SHAPED GLASS TUBE
RUBBER TUBING
TEST TUBE
SMALL TEST TUBE
WATER TANK

2. Place the black powder to a depth of about 5 mm in the large test tube.

3. Completely fill the small test tubes with water and invert them in the water tank.

4. Put a glowing splint into the top of the large test tube and observe what happens. Record your observations.

5. Pour approximately 50 ml of Liquid Z into the tube containing the black powder. Quickly cap the test tube with the stopper to which the glass tube and rubber tubing are attached. Place the end of the rubber tubing under the surface of the water in the tank. After there has been some activity in the water for about ten seconds, place the end of the rubber tubing under the mouth of one of the small test tubes. When activity in the small test tube seems to have stopped, cap the test tube with a small stopper. In the same way fill the other small test tubes.

6. Place a glowing splint into the mouth of the first small test tube and observe what happens. Record your observations below.

7. Repeat this procedure for one other test tube and record your observations.

8. Repeat Item 6, using a burning splint. Record your observations.

9. Using the last tube, observe whatever other characteristics of the gas you can. Record your observations.

INTERPRETATION

1. What evidence do you have that a change took place during this investigation?

2. What happened in the small test tubes ?

3. What explanation can you give for the way the water in the small test tubes acted?

4. State what you observed happening in the large test tube when Liquid Z was added.

5. How can the particle theory explain the changes you have observed in the investigation?

2-27

GAS FROM LIQUID W AND A RIBBON

MATERIALS

- ribbon, 25 cm
- rubber tubing
- water tank
- rubber stopper, #4, one-hole
- glass bend
- wooden splint
- Liquid W, 25 ml
- ring stand and base
- burette clamp
- test tubes, 1 x 150 mm, 3
- rubber stopper, #1, solid, 3
- test tube, 25 x 200 mm
- goggles

PROCEDURE

Perform all the following tasks with proper safety precautions.

1. Using the materials listed above, set up the apparatus for collecting a gas by water displacement.
2. Add Liquid W to the ribbon in the large test tube and collect the resulting gas.
3. Determine whether the gas is heavier or lighter than air.
4. Determine whether the gas is explosive or whether it will support combustion.
5. Fill in the chart found in 2-22.

INTERPRETATION

______ Gas is lighter than air.

______ Gas is heavier than air.

______ Gas will support combustion.

______ Gas is explosive.

2-28

DISTINGUISHING AMONG SUBSTANCES

You have broken down several substances and produced new substances from them. Now you will attempt to identify and classify these substances.

PROCEDURE

1. Use the key below to identify the initial and final substances you recorded in the chart in 2-22. In the chart on the next page write the name of each substance you can identify from this key.

Substance	Description
Oxygen	Colorless gas that is heavier than air Causes a glowing splint to continue to glow or burst into flame
Hydrogen	Colorless gas that is lighter than air Pops when tested with a burning splint
Mercury	Silver gray liquid Density of 13.6 g/ml Very cohesive
Sulfuric acid	Strong acid made of hydrogen, sulfur, and oxygen Very corrosive
Chlorine	Greenish-yellow gas that is heavier than air
Magnesium	Shiny light ribbon that reacts with acids
Mercuric oxide	Orange-red powder made up of oxygen and mercury
Hydrogen peroxide	Liquid made up of hydrogen and oxygen Bleaches materials Breaks down when exposed to sunlight for long periods of time
Water	Colorless liquid Tasteless Odorless Composed of hydrogen and oxygen
Sodium hydroxide	White solid that easily dissolves in water Composed of sodium, hydrogen, and oxygen

Investigation	Initial Substance(s)	Final Substance(s)
Heating an Orange-Red Powder		
Liquid X and Zinc		
Electrolysis		
Bubbling Waters		
Gas from Liquid W and a Ribbon		

2. Look over the list of substances in the chart above. Try to classify them under one of the headings in the chart below.

Substances That Were Broken Down	Substances That Were Not Broken Down

INTERPRETATION

1. What do all of the substances that were broken down have in common?

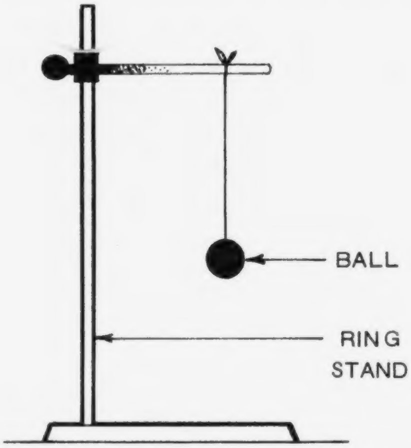
2. What do all of the substances that were not broken down have in common?

RUBBING SUBSTANCES TOGETHER

You have discovered that a compound is a substance that can be broken down into simpler substances by a chemical reaction and that an element is a substance that cannot be broken down into simpler substances by a chemical reaction. However, scientists have found evidence that even elements are not as simple as was once thought. In this investigation you will see some of that evidence.

MATERIALS

- cotton cloth
- wool cloth
- cellulose acetate strip (clear)
- vinylite strip
- ring stand
- clamp holder
- string
- styrofoam ball



PROCEDURE

1. Attach the styrofoam ball to the ring stand with a piece of string, as shown in the diagram.

2. With a dry hand touch the ball and then the acetate strip. Hold the acetate strip 5 cm from the ball and slowly bring it closer to the ball. What do you observe?

3. With a dry hand touch the ball and then the vinylite strip. Hold the vinylite strip about 5 cm from the ball and slowly bring it closer to the ball. What do you observe?

4. With a dry hand touch the ball momentarily. Remove your hand from the ball. Have another member of the group rub the acetate strip with the cotton cloth. Now for just an instant touch the ball with the acetate strip. Quickly rub the acetate strip again and hold it about 5 cm from the ball. Slowly bring the strip closer to the ball. What do you observe?

5. With a dry hand touch the ball momentarily. Remove your hand from the ball. Have another member of the group rub the vinylite strip with the wool cloth. Touch the ball with the vinylite strip. Quickly rub the vinylite strip again with the wool cloth. Hold the vinylite strip about 5 cm away from the ball and slowly bring the strip closer to the ball. What do you observe?

INTERPRETATION

1. What evidence do you have that the rubbing did or did not cause a change in the ways the ball and the strips reacted to each other?

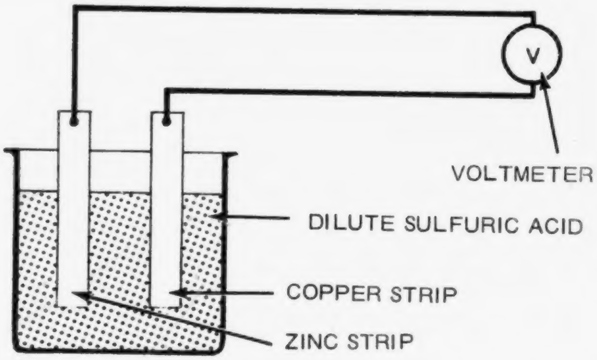
2. If you did note a change in the ways the ball and the strips reacted, try to explain this change using the particle model of matter.

ELECTRICITY FROM CHEMICAL SUBSTANCES

In a previous investigation you used electricity to separate water molecules into smaller particles. In this investigation you will use some common chemicals to produce electricity.

MATERIALS

beaker, 400 ml
zinc strip
copper strip
wire leads fitted with alligator clips, 2
voltmeter
dilute sulfuric acid
goggles



PROCEDURE

1. Pour dilute sulfuric acid into the beaker until it is three-fourths filled.

2. Place the strips of copper and zinc in the acid. They should not touch each other.

3. Use a wire lead to connect the top of the copper strip to the positive terminal on the voltmeter. Connect the zinc to the other terminal on the meter.

4. Observe the copper and zinc. Record any changes you notice.

5. Record the voltage indicated on the meter.

INTERPRETATION

1. Assume that the meter indicates the flow of "particles of electricity." What might be the source of the particles?

2. Recall the demonstration on the electrolysis of water. What was the source of "electrical particles" in that investigation?

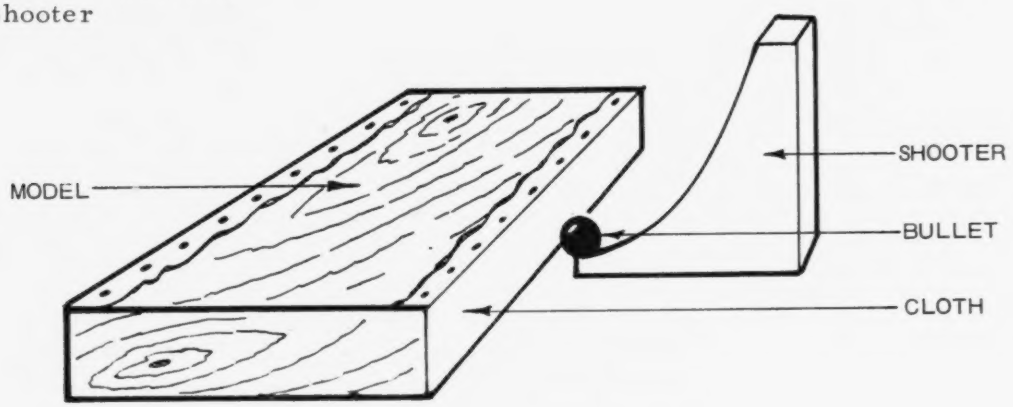
3. Are these "electrical particles" similar to any of the particles you have previously studied? Explain your response.

A BIG MODEL OF A SMALL SHOOTING RANGE

From a great many observations you have probably concluded that matter is made of particles. Observations of chemical changes by which one kind of matter changes into another kind have suggested to you that certain particles can be torn apart into smaller particles. And recently you found that matter has electrical properties, which might suggest the presence of still smaller particles. Today you will look at a model that may help you further understand the particulate nature of matter.

MATERIALS

model apparatus
"bullet" (marble)
shooter



PROCEDURE

1. Aim the shooter of the apparatus so that the "bullet" will travel through the model.

2. Predict where the "bullet" should come out of the model.

3. Shoot the "bullet" by placing it at the top of the shooter.

4. Record your data in the chart on the next page by placing a check in the appropriate column.

5. Repeat the above procedure using different positions and directions for the shooter until you have completed the chart.

Trial	"Bullet" Came out Where Predicted	"Bullet" Did Not Come out Where Predicted
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		

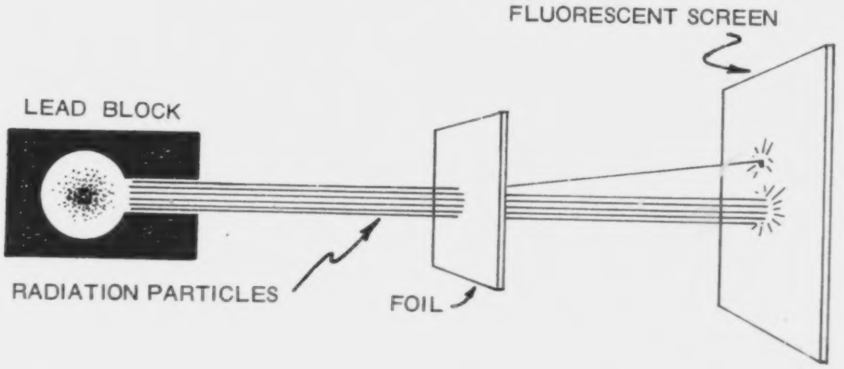
INTERPRETATION

1. Based on the results of your 25 trials, what structure do you think the inside of the model has?

2. If you have gained enough information from your trials, make a diagram of the interior of the model.

3. In the early 1900's an Englishman, Ernest Rutherford, conducted an experiment in which he got results similar to those you got with your experiment today. Look at the diagram of his apparatus and the data he got by shooting his "bullets" 16,000 times.

Rutherford's Apparatus



"Bullets" Used	Number of "Bullets" That Passed Straight Through	Number of "Bullets" That Were Deflected
16,000	15,998	2

4. Rutherford's thin foil was a solid piece of metal 2,000 atoms thick. If you were Rutherford and had collected this data what would you conclude about the structure of an atom?

5. Can you explain why this investigation is called "A Big Model of a Small Shooting Range"?

A REAL PUZZLER

Below is a set of statements made by a student who did the investigation you are going to do today. Complete the investigation and see whether or not you agree that his statements are supported by this investigation.

1. Bubbles move through the liquid.
2. Molecules have spaces between them.
3. Molecules move farther apart when heated. They move closer together when cooled.
4. A brown gas forms above the blue liquid.
5. The colorless liquid is not water.
6. The atoms of an element are all the same kind.
7. The shiny beads were made of copper.
8. Sometimes a convex meniscus was evident in Test Tube B.
9. In a compound the atoms are of two or more different kinds.
10. Molecules are in motion.
11. Molecules exert forces.
12. Initially there was a solid in Test Tube A and a liquid in Test Tube B.

MATERIALS

collecting bottle
Test Tube A
Test Tube B
goggles

PROCEDURE

1. Obtain Test Tube A and Test Tube B from the designated areas.
2. Observe the two test tubes and record your observations.

3. Carefully slide the contents of Test Tube A into Test Tube B and observe Test Tube B for 15 minutes. Record your observations at the intervals listed below.

   0 - 5 minutes:

   5 - 10 minutes:

   11 - 15 minutes:

INTERPRETATION

1. Based on the observations you made, which of the statements in the introduction seem to be supported? Indicate your answer by listing the numbers of the statements.

2. Which of the statements in the introduction do not seem to be supported by your observations?

3. For each statement that you think is supported, state a reason to explain your thinking.

SCIENTIFIC MODELS

Your teacher will give you directions for studying one or more big ideas that early thinkers and scientists created to explain some part of the natural world. These big ideas are called scientific models.

1. Which model did you investigate?

2. Who developed the model and when was the work done?

3. Give a short statement telling what the model explains.

4. What observations were used for developing the model?

5. What observations, if any, were not explained by the model?

6. What major changes, if any, have been made to the model?

7. How well do scientists today accept the model? Why does the model have this degree of acceptance?

2-34

ATOMIC MODELS

To summarize your study of Phase Two of the seventh grade science course, "A Search for Structure," you will look at various models of the atom that have been proposed by scientists. Your teacher will give you specific directions.

OBJECTIVES
A Model of Matter

1. Identify the appropriate sense needed to make an observation.

2. Distinguish between an observation and non-observation.

3. Name the qualitative characteristics of objects and/or events using one or more of the senses.

4. Distinguish among objects on the basis of observable characteristics.

5. Demonstrate the ability to use instruments in making observations.

6. Demonstrate the ability to select the proper instrument to extend observations of qualitative characteristics.

7. Distinguish between qualitative and quantitative characteristics of objects.

8. Demonstrate a procedure for using the metric system to determine length.

9. Demonstrate a procedure for measuring area.

10. Demonstrate a procedure for measuring volume.

11. Demonstrate a procedure for measuring mass.

12. Demonstrate the ability to select the appropriate instrument to measure the quantitative characteristics of objects and/or events.

13. Describe qualitative and quantitative characteristics of objects and/or events.

14. Distinguish among objects on the basis of density and specific gravity.

15. Distinguish among objects on the basis of physical properties.

15a. Demonstrate the ability to classify objects and/or events according to observable properties and behavior.

16. Construct a chart of paired measurements.

17. Construct a chart of paired measurements after first ordering one of the sets of measurements.

18. Distinguish the dependent variable from the independent variable, given a chart of paired measurements with one of the sets of data ordered.

19. Apply the rule that the scale for the independent variable is ordered on the horizontal axis of a graph and the scale for the dependent variable is ordered on the vertical axis.

20. Identify a point on a graph, given a pair of measurements.

21. Construct a line graph of ordered pairs.

22. Construct a statement that describes a set of data.

23. Construct one or more ideas from a table and a graph.

24. Construct one or more ideas from a set of observations.

25. Identify the data that supports an idea.

26. Distinguish whether or not an idea is supported.

27. Order a set of ideas from least to most probable.

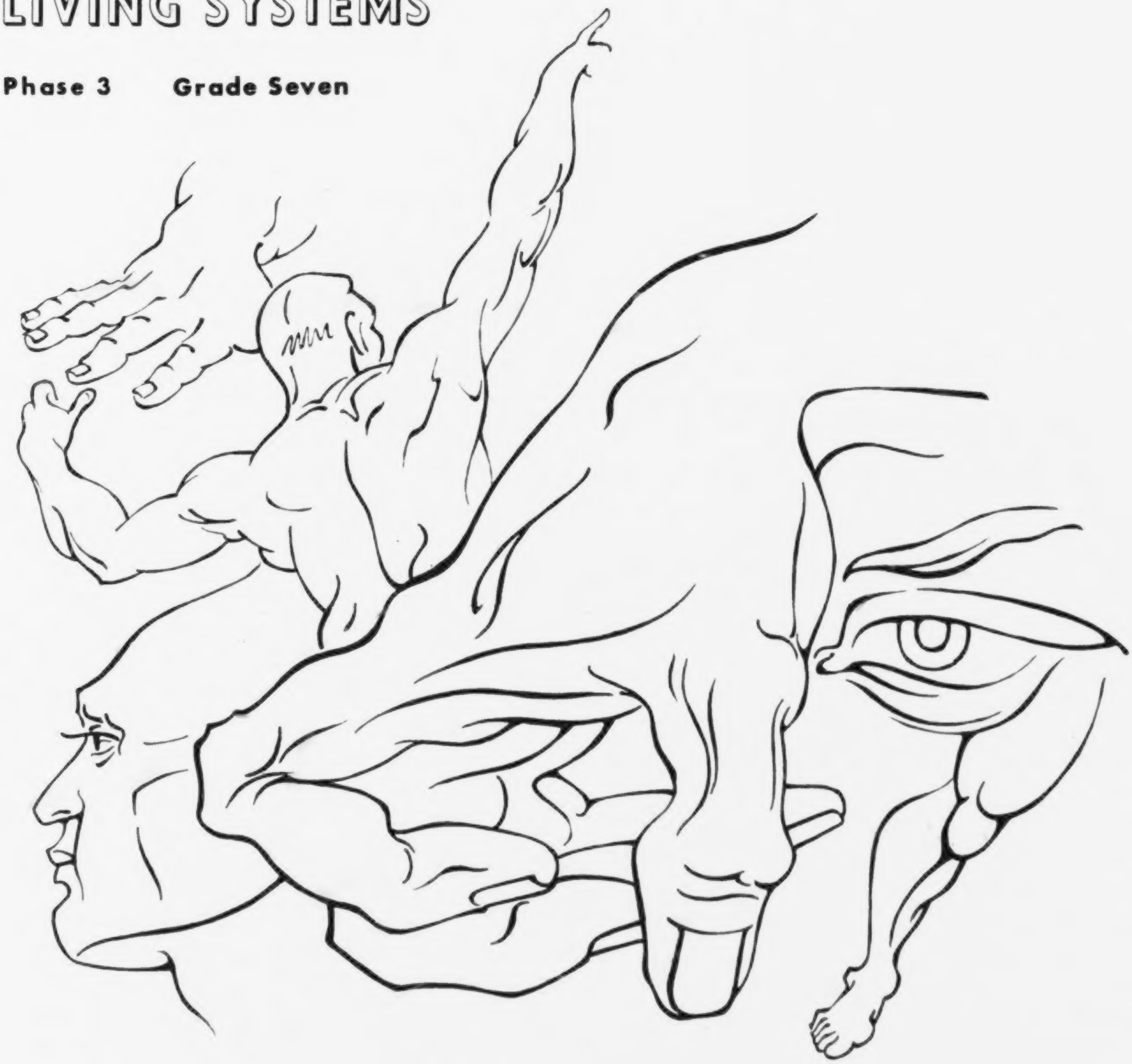
28. Construct an investigation and demonstrate the procedures to test an idea.

A SEARCH FOR STRUCTURE

A STUDENT MANUAL FOR
JUNIOR HIGH SCHOOL SCIENCE

LIVING SYSTEMS

Phase 3 **Grade Seven**



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A PROBLEM

John and Alice are each 12 years old. One day in a science class the teacher took their pulse rates. He found that John's rate was 72 pulses per minute and Alice's was 80 pulses per minute. The teacher asked the class to try to explain the difference. Can you?

In Phases One and Two of your seventh grade science program you gained some understanding of the ways in which a scientist works. You practiced investigative skills and developed ideas or scientific models to explain your observations of matter. In Phase Three you will use these skills and ideas in studying living things.

What do you mean when you say that a thing is "living"? To begin your study of Phase Three you will need to think about how living things are distinguished from non-living things. Then you will concentrate your attention on the living thing that is most important to you--the human body. The final stage of your work will give you an opportunity to plan investigations of ways to take care of your own human body.

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3-1

GROUPING OBJECTS

In Phase Two you developed a model of matter. To do this you placed a series of observations into groups. Grouping observations helped you to see relationships among them. Whether you are working with observations or objects, the process of putting things into groups is called classification. In this activity you are asked to classify some objects into two groups.

PROCEDURE

1. Carefully observe the objects you have been given. As you look at the objects, keep these questions in mind:
    a. What are some characteristics of each object?
    b. In what ways are the objects alike?
    c. In what ways are the objects different?
2. Think of a way to separate the objects into two groups. List the names of the objects in Part I of the chart below:

	Group A	Group B
Part I		
Part II		

3. Study Part I of your chart. How are the objects in Group A different from the objects in Group B? Your answer must be clear enough so that another student can use it to place other objects in the proper group.

4. Look about the room. List below the names of six other objects which you can see.

5. Exchange charts with another student. Using his grouping system, place your six objects of Item 4 in Part II of your chart.

TESTING FOODS

You have found that it is not easy to decide what is living and what is not living. Things are not always what they seem to be. When scientists try to distinguish between living and non-living things, they look for certain characteristics. One of these is the ability of living things to get food and to use it for growth and energy.

What do you really know about the food you eat? All foods contain useful chemicals called nutrients. You can find out what nutrients are in foods by making some simple tests.

Part A: Testing for Nutrient A

MATERIALS

food samples
newsprint paper
egg white, hard-boiled

PROCEDURE

1. Can you name a nutrient that may be present in all of the following foods?
    a. butter
    b. bacon
    c. peanut butter
    d. fried potatoes
2. Use a sample of one of these foods to make the following test for Nutrient A.
    a. Rub a small piece of the food on newsprint paper. Wait a few minutes for the paper to dry.
    b. Hold the paper up to the light. What do you observe?

> Note: A food that contains Nutrient A will always give this result.

3. Rub a piece of the white of a hard-boiled egg on the paper. Wait for the paper to dry. Does the egg white contain Nutrient A?

4. Repeat this test using other food samples that your teacher will give you. Record your results in the chart on Page 6.

Part B: Testing for Nutrient B

MATERIALS

food samples
iodine
egg white, hard-boiled

PROCEDURE

1. All the following foods have one thing in common; they contain Nutrient B.
   a. bread
   b. cracker
   c. noodles
2. Use a sample of one of these foods to make the following test for Nutrient B: Place a drop of iodine on the sample of the foods. What happens?

> Note: A food that contains Nutrient B will always give this result.

3. Place a drop of iodine on a small piece of the white of a hard-boiled egg. Does the egg white contain Nutrient B? Explain your answer.

4. Repeat this test using other food samples that your teacher will give you. Record your results in the chart on Page 6.

Part C: Testing for Nutrient C

MATERIALS

test tubes, 2
Biuret solution
water
egg-white solution

PROCEDURE

1. All the following foods have one thing in common; they contain Nutrient C.

   a. egg white
   b. milk
   c. liver
   d. apple

2. Make the following test for Nutrient C:

   a. Add 10 drops of Biuret (by-a-RET) solution to a test tube containing 5 ml of water. What do you observe?

   b. Pour 5 ml of egg-white solution into a second test tube. Add 10 drops of Biuret solution. How does the color of the liquid compare with the color in the first test tube?

> Note: A food that contains Nutrient C will always give this result.

3. Repeat this test using the other food samples that your teacher will give you. Record your results in the Chart on Page 6.

Testing for Food Nutrients

Directions: In the first column list the names of the food samples that you were given to test. In the other columns place a + if the nutrient is found in the food.

Food Sample	Nutrient A	Nutrient B	Nutrient C

INTERPRETATION

Nutrients A, B, and C have scientific names. If you know these names write them below.

RELATED ACTIVITY

1. Read Pages 141-146 in Pathways in Science, Biology 1 to check your answers.

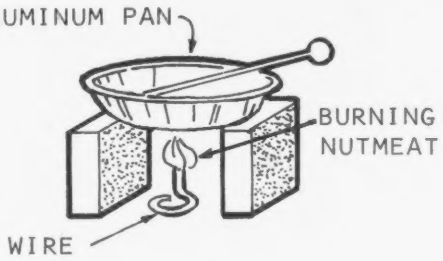
2. What other nutrients did you discover in your reading? List their names.

3-3

A TEST FOR ENERGY

You have learned to identify the nutrients that provide the body with energy. The body releases this energy by a chemical process much like burning. In this investigation you will test three different types of nutmeats to determine which is the best energy source.

MATERIALS



aluminum pan, 9 in
thermometer
large paper clip or wire support
matches
blocks to support pan, 2
graduated cylinder, 250 ml
nutmeats, 3
asbestos pad

PROCEDURE

1. Arrange the equipment as shown in the diagram. Place the entire set up on an asbestos pad.

2. Place 200 ml of water in the pan. Record the temperature of the water in the chart. This is the starting temperature.

3. Place Nutmeat A under the pan on the wire support.

4. Touch a lighted match to the nutmeat until it begins to burn.

5. Record the change of temperature of the water every 30 seconds while Nutmeat A is burning. Record the data in the chart.

6. Repeat Procedures 3, 4, and 5, using Nutmeats B and C.

7. Construct a graph of the data.

Temperature Changes in Water Caused by Burning Nutmeat

Time	Nutmeat A	Nutmeat B	Nutmeat C
Start			
30 sec			
1 min			
30 sec			
2 min			
30 sec			
3 min			
30 sec			
4 min			
30 sec			
5 min			

INTERPRETATION

1. Which nutmeat released the most energy? Explain your answer.

2. What are some sources of error in this investigation?

3. What evidence suggests that a process much like this takes place in our bodies?

3-4

DIET AND GROWTH

You have found that energy can be obtained from a nutrient. But there is still another reason for eating--that is, for taking in nutrients.

PROCEDURE

1. Read the following:

> A litter of puppies was divided into two groups of five each. Each group of puppies weighed a total of 55 kilograms in January. Group A was fed 1000 grams of dog food each day. Group B was fed 1250 grams of dog food each day. For one year weights of the two groups were recorded at the end of each month:

Month	Weight of Group A	Weight of Group B
January	55 kg	55 kg
February	60 kg	61 kg
March	67 kg	70 kg
April	75 kg	78 kg
May	82 kg	88 kg
June	89 kg	97 kg
July	94 kg	106 kg
August	98 kg	112 kg
September	102 kg	117 kg
October	106 kg	120 kg
November	109 kg	122 kg
December	111 kg	124 kg

2. On the grid below construct line graphs showing the increases in weights of each group. Use lines of different colors to represent each group of dogs.

3. What was the total weight change during the year for each group?

4. Which group showed the greater increase in weight?

INTERPRETATION

1. Explain the difference in weight gain between the two groups.

2. If the dogs in Group A had been fed 1250 grams of food every day, what do you think would have happened? Explain.

3. If for one year you ate smaller meals than normal, what might happen to your weight?

4. If you ate larger meals than normal, what might happen?

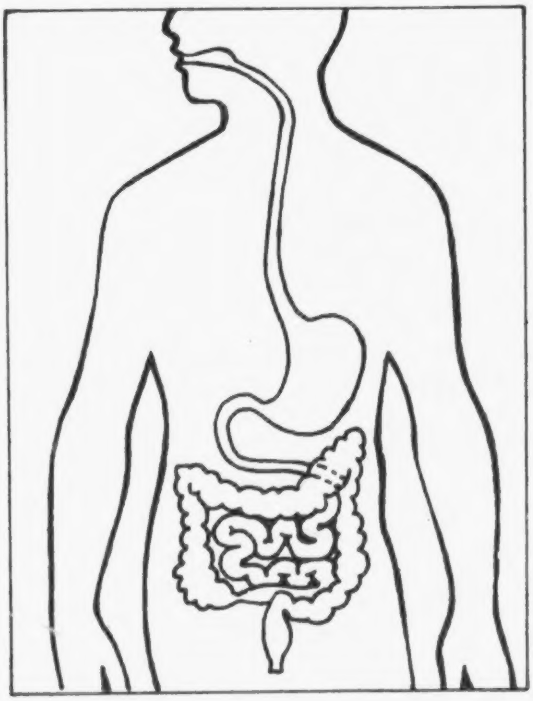
3-5

A ONE-WAY STREET

Living things use food for growth and as a source of energy. First, however, you and all animals must eat the food; in other words, you must start it through the food tube.

PROCEDURE

1. Look at the diagram of the human food tube:



2. Using colored pencil or ink, carefully draw a line in the diagram to show the path of food as it passes through the food tube.

INTERPRETATION

1. Are the parts of the food tube the same shape and size? Explain.

2. Is there any place where food leaves the food tube to enter other parts of the body?

3. What must happen to the food you eat before it can be delivered to other parts of the body?

PASSING THROUGH

Perhaps you remember that sugar is one kind of carbohydrate. Starch is another kind of carbohydrate. Do both starch and sugar pass through the walls of the food tube in your body?

MATERIALS

string, one long and
  one short piece
dialysis tubing, 15 cm
cornstarch solution
medicine dropper
sugar solution
ring stand and clamp
large beaker
soda straw
glass slide
iodine in dropping bottles

PROCEDURE

Figure 1

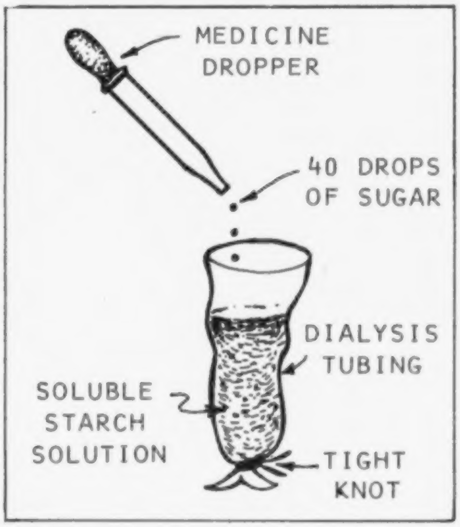
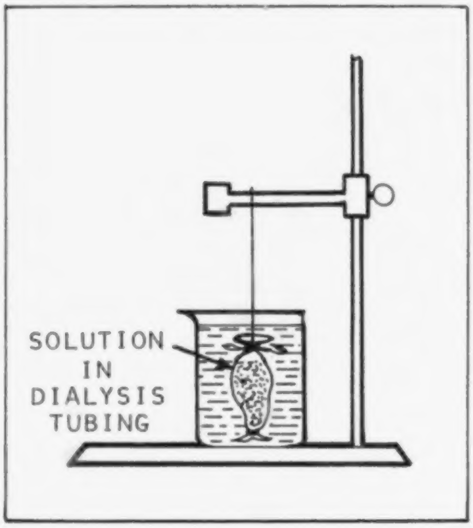

MEDICINE DROPPER
40 DROPS OF SUGAR
DIALYSIS TUBING
SOLUBLE STARCH SOLUTION
TIGHT KNOT

Figure 2


SOLUTION IN DIALYSIS TUBING

1. Tie the short string very tightly at a point about 1 cm from the end of a piece of dialysis (dye-AL-eh-sis) tubing. Pour starch solution into the tubing to within 5 cm of the top, as shown in Figure 1. Add about 40 drops of sugar solution to the tubing.

2. Tie the top of the tubing with the long string. Rinse the tubing under running water to remove any sugar or starch that may have spilled on the outside.

3. Place the tube in a beaker of water as shown in Figure 2. Make certain that the solution in the tubing is beneath the level of the water in the beaker.

4. After 15 minutes dip a soda straw into the beaker. Hold your thumb over the end of the straw. Lift the straw from the beaker and allow the liquid to drop on your tongue. Is there sugar present?

5. Use the straw to get a few more drops of the liquid. Place these drops on a glass slide. Test with iodine to see if starch is present.

INTERPRETATION

1. What substance passed through the dialysis tubing?

2. What substance did not pass through the dialysis tubing?

3. From the evidence of the investigation, which molecules do you think are larger, starch or sugar?

4. The lining of your food tube acts toward starch and sugar much as does the dialysis tubing. What then must happen to starch molecules in your food tube before starch can be used in all parts of your body?

3-7

AN EFFECT OF CHEWING

Starch molecules must be changed before they can pass through the wall of the food tube. And molecules of many other nutrients must be changed also. This process of changing food so that it can be used by the body is called digestion. One step of digestion takes place in your mouth.

MATERIALS

glass slides, 3
medicine droppers, 3
sugar solution
starch solution
saliva
iodine in a dropper bottle
toothpicks, 3
small test tubes, 15 x 100 mm
Benedict's solution in a dropper bottle
test tube tongs
heat source
test tube rack
goggles

Part A

PROCEDURE

1. On a glass slide place a drop of sugar solution; on another slide place a drop of starch solution, and on a third slide place a drop of fresh saliva. To the drops on each slide add a drop of iodine. With a clean toothpick mix the iodine with the other liquids. On the chart on the next page record the results, using a check (✓) to show a color change and a zero (0) to show no change.

2. Place about 20 drops of a starch solution and 5 drops of Benedict's solution in a test tube. Follow your teacher's directions for heating the mixture. Record the results on the chart. USE GOGGLES WHEN HEATING A SUBSTANCE!

3. Repeat Item 2 using a sugar solution instead of a starch solution. Record the results on the chart.

4. Repeat Item 2 using a saliva solution instead of starch. Record the results on the chart.

	Substances Tested	Results	
		Iodine	Benedict's Solution
Part A	Starch		
	Sugar		
	Saliva		
Part B	Starch and saliva		

INTERPRETATION

1. How did you test for starch?

2. How did you test for sugar?

3. Does saliva contain sugar? Does it contain starch? Explain your answers.

Part B

MATERIALS

test tube, 15 x 100 mm
saliva
starch solution
medicine dropper
glass slide
iodine
toothpick
test tube tongs
heat source
goggles

PROCEDURE

1. Collect saliva in a test tube to a depth of 1 cm.

2. Add 20 drops of starch solution to the saliva. Roll the test tube between your palms for about a minute.

3. Place a drop of the mixture on a glass slide and test with iodine as you did in Item 1 of Part A. Record your results on the chart.

4. Use the method of Item 2, Part A, to test the mixture with Benedict's solution. Record your results on the chart.

INTERPRETATION

1. Does the mixture contain starch? Does it contain sugar? Explain your answers.

2. What did saliva do to the starch?

3. How does thorough chewing help you to digest starch in your food?

3-8

THROUGH THE AGAR BLOCK

Saliva causes starch to change to sugar. However, all of the starch is seldom changed to sugar. Why is this true?

MATERIALS

agar blocks, 2 sizes
Liquid R, 150 ml
beaker, 250 ml
plastic spoon
container of water
paper towels
razor blade, single-edge

PROCEDURE

1. Examine your two agar blocks. How do they compare in size and color?

2. Place both blocks in the beaker containing approximately 150 ml of Liquid R. What change occurs in the blocks?

3. After 10 minutes use a plastic spoon to remove the blocks from Liquid R. DO NOT THROW AWAY THE LIQUID R. Wash the blocks by dropping them into a container of water. Using the plastic spoon remove the blocks from the water and place them on a paper towel. Does the water remove the color?

4. Using a razor blade, cut the larger block of agar in half. From one of the halves cut a thin slice from the inner side. Place this slide on a paper towel. Wash the razor blade and blot it on a paper towel.

5. Repeat Item 4, using the other agar block.

6. Make diagrams of the two slices. Shade the colored areas.

INTERPRETATION

1. Which of the two blocks has a larger area not penetrated by Liquid R?

2. Suppose the blocks had been made of starch, and Liquid R had been saliva. In which block would the greater amount of starch have been digested by saliva? Explain.

3. Suppose that you have two cups, A and B, each containing saliva. Then you place equal amounts, by weight, of starch in each cup. In Cup A you place one large block of starch. In Cup B you place an equal weight of starch, but it is divided into many small blocks. At the end of five minutes which container would have the least starch?

4. After the five minutes which of the cups, A or B, would contain the most materials that could pass through the walls of the food tube?

5. As you eat, what do you do to foods to help digest them more quickly?

3-9

SOLUTIONS AND DIGESTION

You have found that saliva requires less time to change small particles of starch into sugar than large particles of starch. Is particle size the only thing that determines the speed at which substances change?

MATERIALS

- beakers, 250 ml, 4
- heat sources
- ring stands and rings, 2
- goggles
- lemon drops, 4
- timer
- glass rod
- beaker tongs

PROCEDURE

1. Pour water into each of four beakers until they are three-quarters full.

2. Place two of the beakers over a heat source and heat to boiling.

3. Place a lemon drop into one of the unheated beakers. On the chart on the next page record the time required for the lemon drop to dissolve.

4. Place another lemon drop into another unheated beaker. Using a glass rod, stir constantly until the lemon drop is completely dissolved. Record the time required for the lemon drop to dissolve.

5. When the water in one of the beakers is boiling vigorously, place a lemon drop into it. Immediately remove the beaker from the heat source. Record the time required for the lemon drop to dissolve completely.

6. Into the boiling water in the other beaker place a lemon drop. Immediately remove the beaker from the heat source and stir the water constantly until the lemon drop is completely dissolved. Record the time required for the lemon drop to dissolve.

Beakers	Time
Unheated	
Unheated, stirred	
Heated	
Heated, stirred	

INTERPRETATION

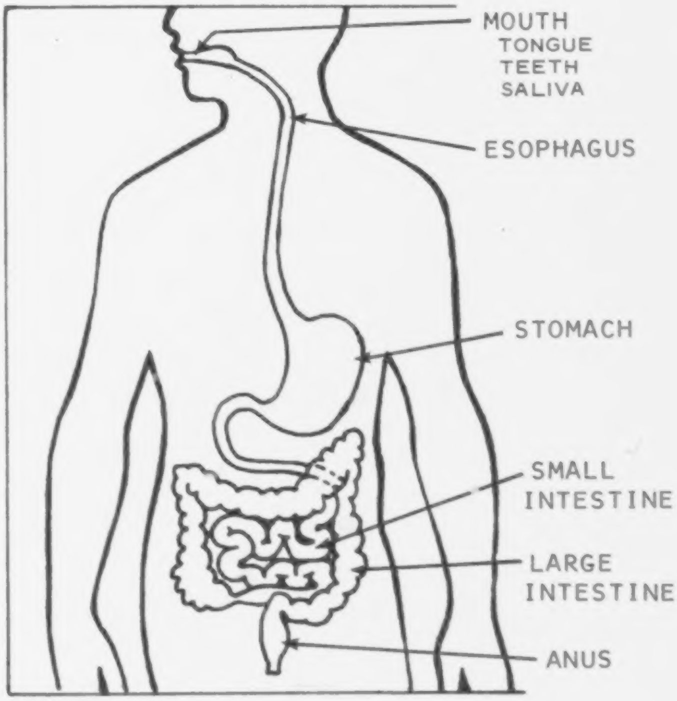
1. Look over the data in the chart. What statements can you make about the dissolving time of lemon drops?

2. Activities in your stomach are somewhat similar to those in Procedure Item 6. What two things does your stomach do to speed the digestion of foods?

3-10

STRUCTURE FOR A PURPOSE

You have found that certain things must happen to foods before they can pass through the walls of the food tube. Each part of the food tube does something special to bring about these changes. Let's follow the path food takes and see how the structure of the food tube helps produce these changes.


MOUTH
TONGUE
TEETH
SALIVA
ESOPHAGUS
STOMACH
SMALL INTESTINE
LARGE INTESTINE
ANUS

PROCEDURE

The above drawing represents the food tube. Some parts have been labeled. Examine the picture in order to answer the interpretation questions.

INTERPRETATION

1. How do your teeth help to prepare food for swallowing?

2. What is added in your mouth that helps food to slide down the food tube?

3. How does your tongue help to get food down the food tube?

4. If you eat a slice of bread, what happens to the starch in the bread while it is in your mouth?

5. Through what part of the food tube must the bread travel to get from your mouth to your stomach?

6. Examine the shape of the stomach and compare it with the parts of the food tube above and below it. How do you think this shape is suited to the activities of the stomach?

7. Much of the chemical digestion of nutrients occurs after the food leaves the stomach. In what part of the food tube does this chemical digestion occur?

8. Is digested food solid, liquid, or gas?

9. When foods have been digested they are able to pass through the walls of the food tube. In what part of the food tube do you think digested foods enter the body?

10. Why do you think the small intestine is so long?

11. Is everything you eat digested? Explain.

12. If some foods are not digested, what is this undigested part called?

13. Where does the undigested food go after it leaves the small intestine?

14. What do you call the opening that allows you to get rid of the undigested foods?

15. The food tube is usually called the digestive system. Why is this an appropriate name?

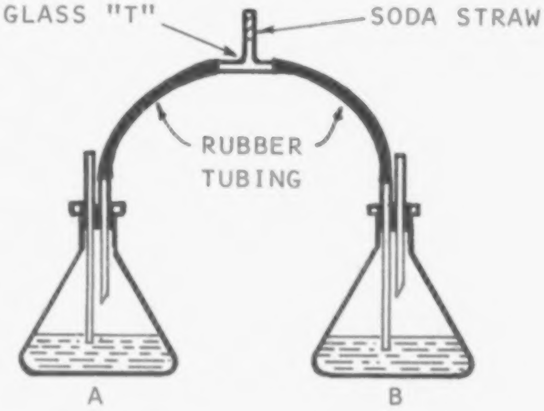
3-11

A BODY WASTE

Digestion provides the fuel for your body. The use of any fuel results in the production of wastes. In this investigation you will learn about one waste material resulting from the use of your body fuels.

MATERIALS

flasks, Erlenmyer, 250 ml, 2
glass tube, straight, 15 cm, 2
glass tube, straight, 8 cm, 2
glass tube, "T"
rubber tubing
plastic soda straw
bromthymol blue
  solution, 250 ml



PROCEDURE

1. Pour 125 ml of bromthymol blue solution into each flask and assemble the equipment as shown in the diagram above. Notice that the arrangement of glass tubing is different in each flask.

2. Close the rubber tube from Flask B by pinching it between your thumb and forefinger. Inhale through the solution in Flask A by drawing air in through the mouthpiece. Immediately pinch the rubber tube from Flask A. Release the rubber tubing from Flask B. Exhale through the solution in Flask B.

3. Repeat Procedure Item 2 until no further changes occur in the solutions in the flasks.

4. Describe any changes you observed in the solution in Flask A.

5. Describe any changes you observed in the solution in Flask B.

INTERPRETATION

1. In this investigation which flask showed a color change? Why?

2. What is the waste material in this investigation?

3. Why is this material found in exhaled air?

3-12

MEASURING CARBON DIOXIDE

To identify the carbon dioxide exhaled during breathing you observed a change in an indicator, bromthymol blue. You can use another indicator to measure roughly the amount of carbon dioxide exhaled.

MATERIALS

graduated cylinder
barium hydroxide solution, 100 ml
test tubes, 15 x 100 mm, 4
grease pencil
soda straws, 4
test tube rack
metric ruler

PROCEDURE

1. Pour 25 ml of barium hydroxide into each of the test tubes. Using a grease pencil, mark the test tubes as follows: 0 sec, 15 sec, 30 sec, and 45 sec. Place a straw in each test tube.

2. Select one team member to carry out Procedure Items 3, 4, and 5. This person should be able to hold his breath for 45 seconds.

3. Take a deep breath. Immediately exhale all of the air through the straw into the test tube marked "0 sec." Repeat until you have exhaled a total of five breaths through the straw. Place the test tube in the test tube rack.

4. Take a deep breath and hold it for 15 seconds. Exhale into the test tube marked "15 sec." Repeat a total of 5 times. Place the test tube in the test tube rack.

5. Repeat the above procedure, holding your breath for 30 seconds before exhaling. If possible, repeat the procedure, holding your breath for 45 seconds. Allow the test tubes to remain undisturbed overnight.

6. The next day, measure with a metric ruler the amount of white material in the test tubes. Record your data in the chart.

Time Breath Was Held	Mm of White Material
0 sec	
15 sec	
30 sec	
45 sec	

7. What happened when barium hydroxide and carbon dioxide were mixed together in the test tubes?

8. Make a line graph of your data. Be sure to label each axis.

INTERPRETATION

1. Look at your graph. How does the amount of white material change as the length of time air is held in the lungs increases?

2. Did you make a direct measurement of the amount of carbon dioxide exhaled from the lungs? Explain your answer.

3. Why is it necessary that just one member of the team do all the exhaling?

4. Would you expect different data if another team member did the investigation? Why or why not?

RELATED ACTIVITY

To measure the amount of oxygen absorbed by your lungs, carry out the activity on Page 211 of Exploring Life Science by Thurber and Kilburn.

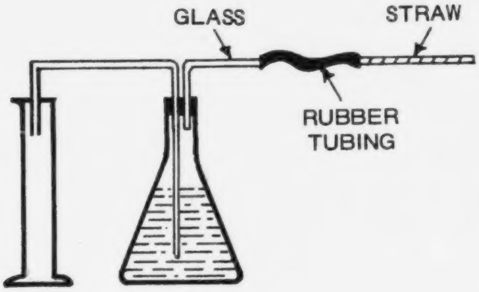
3-13

BREATHING DIFFERENCES

The amount of air you inhale and the rate at which you breathe are affected by many factors. You can investigate one of these factors in the following experiment.

MATERIALS

- graduated cylinder, 100 ml
- colored water
- flask, 1000 ml
- stopper, 2-hole, #9
- glass tubing, 25 cm
- glass tubing, 40 cm
- rubber tubing, 15 cm
- soda straw
- timer



PROCEDURE

1. Pour 900 ml of colored water into the flask and set up the apparatus as shown in the diagram.

2. Using a normal breath of air, exhale through the soda straw at A. This will force some water from the flask into the graduated cylinder.

3. Measure the water in the graduated cylinder. Record the measurement on the first line in the chart on the next page. This amount of water is equal to the amount of air you exhale in a normal breath.

4. Pour the water back into the flask.

5. Repeat Procedure Items 2, 3, and 4 for Trials 2 and 3. Record the data in the chart.

Normal Breathing	Volume of Water in Cylinder
Trial 1	
Trial 2	
Trial 3	
Total Volume	
Average Volume	

6. Find the total volume of water for all 3 trials. Record your answer in the table.

7. Find the average volume of water by dividing the total volume by the number of trials (3). Record your answer in the table.

8. How much air do you breathe in one minute?

   a. Count the number of times you breathe in three minutes. Divide this number by 3. ________________

   b. Multiply this answer by the average volume of water in the cylinder. This will tell you the average volume of air you breathe in one minute. ________________

9. Repeat Procedure Items 2 through 7. However, before exhaling into the straw in each trial, run in place for one minute. Rest for two minutes between trials. Record the measurements in this chart:

Breathing after Exercise	Volume of Water in Cylinder
Trial 1	
Trial 2	
Trial 3	
Total Volume	
Average Volume	

10. How much air do you breathe in one minute when exercising?

    a. Count the number of times you breathe in one minute after one minute of exercise. ____________________

    b. Determine the volume of air you breathe in one minute after one minute of exercise. (See Procedure Item 8b.)

    ____

INTERPRETATION

1. How does the average volume of air you normally breathe in one minute compare with the average volume of air you breathe after exercise?

2. How does your normal breathing rate compare with your breathing rate after exercising?

3. Try to explain the differences in volumes and rates in Interpretation Items 1 and 2.

4. Why were you asked to rest after each trial in Procedure Item 9?

3-14

DIFFUSION OF GASES

You know that carbon dioxide is exhaled from the lungs and oxygen is inhaled. These gases must be exchanged back and forth between the air in the lungs and the blood in the blood vessels. In this exchange they pass through a thin lining or membrane in the lungs by a process called diffusion. What is diffusion? A demonstration will help you understand it.

MATERIALS

balloon
sodium bicarbonate, 10 gms
flask, 250 ml
acetic acid, 10 ml
stopper, No. 6, with glass tubing
string, 10 cm
limewater
quart jars with lids, 2

PROCEDURE

Observe carefully as your teacher performs the following demonstration:

1. Blow up the balloon and let out the air. Repeat this until the balloon can be inflated easily.

2. Place 10 grams of sodium bicarbonate in the flask. Add enough acetic acid to the sodium bicarbonate to start a vigorous reaction. Place the stopper in the flask. Put the mouth of the stretched balloon over the end of the glass tubing. Clamp the mouth of the balloon around the tubing with your fingers so that the gas enters the balloon.

3. When the balloon is approximately half filled, remove it and tie a knot in the end. Tie a string to the knotted end of the balloon.

4. Into each of two jars pour limewater to a depth of approximately 3 cm. Hang the balloon in one jar, making sure it does not touch the limewater. Fasten the lid tightly on both jars. Allow both jars to sit undisturbed over night.

INTERPRETATION

1. What happened to the size of the balloon overnight?

2. What happened to the appearance of the limewater in the jar that contained the balloon?

3. What happened to the limewater in the jar without the balloon?

4. Where did the carbon dioxide that was in the balloon go? How do you know?

5. Carbon dioxide cannot escape from the end of the balloon which is tied. How can the gas escape from the balloon?

3-15

HEARTBEAT

Digestion provides nutrients for your body. Breathing provides oxygen, which allows the body to get energy from the nutrients. Energy is required in all parts of the body; therefore, nutrients and oxygen must be transported to all parts of the body. This is the job of the blood, which is carried through the circulatory system.

You have discovered that breathing rate increases with exercise. It seems probable that exercise might also affect the rate at which the materials that provide energy are transported by the blood. This rate depends upon the rate of heartbeat. Therefore, you can test the following hypothesis:

> Exercise causes the heart to beat more rapidly.

PROCEDURE

1. Devise a method to determine how many times your heart beats in one minute.
2. Use this method to determine the number of times your heart beats in one minute while you are sitting quietly. Record your results.

3. After one minute of exercise (running in place), determine the number of times your heart beats in one minute. Record the results.

4. Place the data from Procedures 2 and 3 on a chart on the chalkboard.

5. Record the data obtained by all the students in the class on this Data Page. Then, by using numerals, order these data from the lowest rate to the highest rate.

DATA PAGE

6. Because of the large number of observations, it is necessary to group the data before you make a graph. To do this, count the number of people who had rates of 55-59 and record the number in the chart below. Do the same for each data group shown in the chart. If some of the rates are greater or lower than those shown on the chart, add data groups.

Beats per Minute	Number of Students	
	Sitting	After Exercising
55-59		
60-64		
65-69		
70-74		
75-79		
80-84		
85-89		
90-94		
95-99		

7. Construct a graph of the data.

8. A graph is a useful way to present data. Scientists also use other ways. For example, the many data recorded in this investigation can be reduced to two numbers that are helpful in describing what the data tell. These numbers are called the range and the average.

   a. The range measures the spread of the data. To find the range, subtract the lowest heartbeat rate from the highest.

   $$\begin{array}{r l} & \text{Largest rate} \\ - & \text{Smallest rate} \\ \hline & \text{Range (Spread of data)} \end{array}$$

   Calculate the range of class data for heartbeat rates while sitting:

   Calculate the range of class data for heartbeat rates after exercise:

   b. The average is found by dividing the sum of the heart beat rates by the number of observations (number of class members).

   $$\text{Average} = \frac{\text{Sum of recorded heart beat rates}}{\text{Number of class members}}$$

   Calculate the average of the class data for heartbeat rates while sitting.

   Calculate the average of the class data for heartbeat rates after exercise.

INTERPRETATION

1. You were asked to test the idea that exercise causes the heart to beat more rapidly. Does your data support this idea? Explain.

2. What could you do to make your conclusion more accurate?

3. Construct a statement that describes what the line graph shows.

3-16

MORE ABOUT HEARTBEAT

Your data have shown a wide range of heartbeat rates between different people. What causes such differences in heartbeat rates? One possible cause is difference in body weight. In this investigation you will test the following hypothesis:

> The rate of heartbeat increases with weight.

PROCEDURE

1. Record your weight and sitting heartbeat rate (from Activity 3-15) on the chalkboard.
2. On the next page construct a chart suitable for organizing the data from all members of the class. Record on the chart the data from the chalkboard.
3. On the following page is a grid. Locate on it the points that show the relationship between weight and heartbeat for each student in your class. Do not connect the points with lines.

DATA PAGE

HEARTBEAT AND WEIGHT

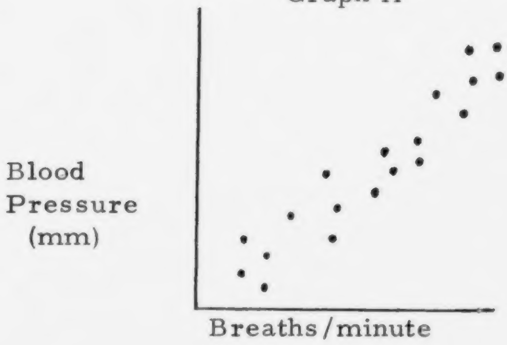
INTERPRETATION

1. Look at the points you have located on the grid. How does their arrangement differ from the arrangement of points on line graphs you have drawn?

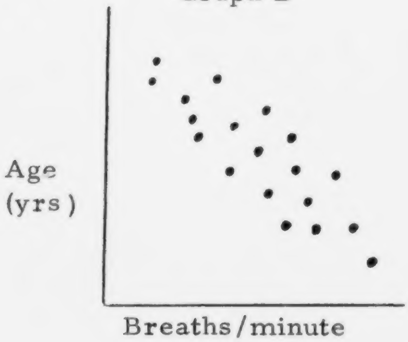
2. Construct a statement that describes the relationship between weight and heartbeat rate.

3. Did you have difficulty constructing the statement? The graph you have made is called a scatter diagram. The points of a scatter diagram are not connected, but the graph can still give a clear picture of a set of data. Some examples will help you see this. Each scatter diagram below describes how one factor affected breathing rate. Each point represents the relationship between the factor and the breathing rate for one person.

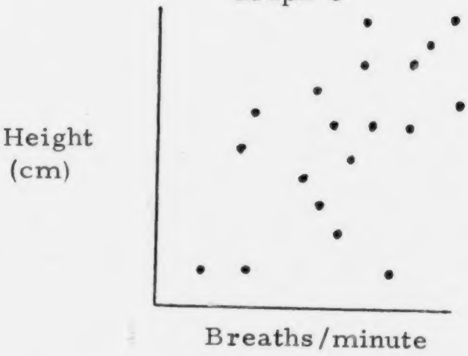
Graph A



Graph B



Graph C



4. Name the factor that each graph shows:

Graph A ______________________

Graph B ______________________

Graph C ______________________

5. Construct statements that show a relationship for each graph.

   Graph A:

   Graph B:

   Graph C:

6. After working with the scatter diagrams, do you want to revise your statement in Interpretation Item 2? If so, restate it below:

3-17

ON YOUR OWN

You have found that exercise has a definite effect on heartbeat rate. The effect of weight on heartbeat is less clear. What other factors might affect the heartbeat rate?

PROCEDURE

1. Consider the following hypotheses about heartbeat:

   a. Tall people have faster heartbeat rates than short people.

   b. People with rapid breathing rates have faster heartbeat rates.

2. Are there any other hypotheses you would like to test? Discuss your ideas with the class.

3. Select one hypothesis and plan an investigation to test it. A review of 3-15 and 3-16 might help you to construct a procedure for your investigation.

4. Write a plan for testing the idea you have chosen.

5. Record the data you gathered to test the idea.

3-18

OBSERVING CIRCULATION

The heartbeats you have been studying push the blood through your circulatory system. To observe the movement of the blood directly you must use some other living organism.

PROCEDURE

Below are suggestions for observing the movement of blood within a circulatory system. Select one of the animals. Then devise an appropriate procedure, collect the necessary equipment, and carry out the observations. References are available to help you in devising procedures for working with the animals.

1. Observe the blood movement in the tail of a goldfish. You may construct a diagram of the vessels through which the blood flows. You may also test the effect temperature has on the rate of blood movement.

2. Observe the blood movement in the tail of a tadpole. You may make observations similar to those suggested for the goldfish.

3. Observe the blood movement in the large vessel that runs lengthwise on the upper side of an earthworm.

REFERENCES

Morholt, et al. A Sourcebook for the Biological Sciences. pp. 245-246

Thurber and Kilburn. Exploring Life Sciences. p. 234

Brandwein, et al. Life, Its Forms and Changes. pp. 382-383

3-19

REACTION

You know that living things require food. They change this food in various ways as it is used for energy and growth. You have learned that the human body needs oxygen for energy production and must get rid of carbon dioxide and other wastes. You have also found that oxygen and nutrients must be delivered to all parts of the body. With all of this knowledge you have made a good start in understanding living things. But there are still other characteristics of living things that can be investigated!

PROCEDURE

Your teacher will perform a demonstration for you. Observe it carefully and answer the following questions:

1. What part of the body was used for each impression?
2. Which impression gave you the most information?
3. Why was it difficult to reach a correct conclusion until several or all sense impressions were pooled?
4. Describe how a person who has lost one of his senses might use others to help identify a substance.

3-20

GOOD TASTE?

What determines whether a taste is sweet, sour, salty, or bitter? Do you use your entire tongue when tasting? In this investigation you will try to answer these questions.

MATERIALS

- tap water
- sugar water
- cotton-tipped swabs
- salt water
- vinegar water
- aspirin water

PROCEDURE

1. Rinse out your mouth with tap water before tasting each kind of solution.

2. In the space below make four diagrams of a tongue. Label the first "Sugar," the second "Salt," the third "Vinegar," and the fourth "Aspirin."

3. Dip a cotton swab in sugar water. Touch the swab to different areas of your tongue. On the first of the diagrams above place an X at those points where you distinctly tasted the sugar.

4. Repeat Item 3, using the other solutions one at a time. Use different cotton swabs for each test. Be sure to record the results of each test on the correct diagram.

5. Match the taste terms of the introduction with each solution. Record the appropriate term under each tongue diagram.

INTERPRETATION

1. a. Was any one part of your tongue particularly sensitive to the sweet taste? If so, what part?

   b. The sour taste? If so, what part?

   c. The salty taste? If so, what part?

   d. The bitter taste? If so, what part?

2. Does any area of your tongue that is sensitive to one taste overlap areas sensitive to other tastes?

3. If you were not able to determine any areas that were particularly sensitive to individual tastes, give a possible reason why you were not able to do this.

4. Is there any part of the tongue that you found not sensitive to any taste?

RELATED ACTIVITY

Determine whether other parts of the mouth are sensitive to taste.

3-21

THE NOSE KNOWS

A human nose may distinguish up to 5,000 different odors. How many different odors can your nose distinguish?

MATERIALS

bottles, labeled A to G

PROCEDURES

1. Open Bottle A and hold it several inches from one side of your nose. Fan the fumes toward your nose.

> NEVER PLACE ANYTHING TO BE SMELLED DIRECTLY UNDER YOUR NOSE.

2. In the second column of the chart below record a description of the odor. Do not try to name the substance in the bottle at this time.

3. Now, in the last column try to name each of the materials that caused the odor.

Bottle	Description of Odor	Name
A		
B		
C		
D		
E		
F		
G		

4. Check with your teacher for the correct names of the materials.

INTERPRETATION

1. Are odors easy to identify? Explain.

2. Does the sense of smell seem to tire quickly?

3. Can your nose tell differences in amounts of an odor? What evidence do you have for your answer?

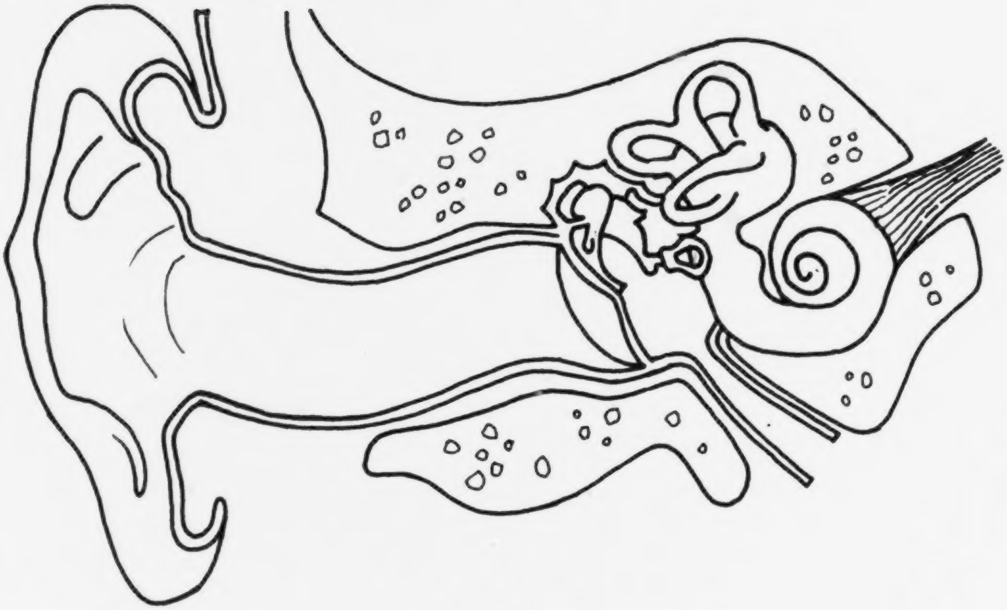
4. Did your classmates agree with you on all odors?

5. When several odors are present, do you smell each one separately or do you smell a mixture of all of them?

6. Why were you able to identify certain odor-producing materials and not others?

3-22

HEARING



The Ear

Part	Function

INTERPRETATION

1. Why is the outer ear the size and shape it is?

2. How can we increase the reflecting surface of the outer ear?

3. Why does a person's ear experience pain when he is making a quick descent in an airplane?

4. How does the use of both ears help humans to hear better?

5. Do you think blind people hear better than people with good sight? Explain.

3-23

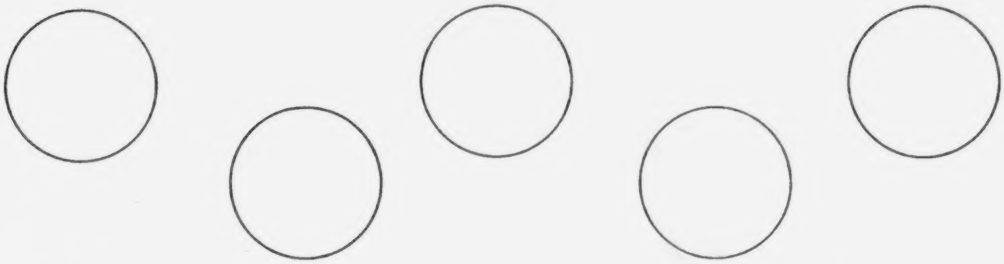
EYE STRUCTURE AND FUNCTION

Nearly all plants and animals, from the simplest to the most complex, respond to light. Many animals not only respond to light but obtain information about things in their environment by detecting the patterns of light reflected from them. This is called the sense of vision.

Part A

PROCEDURE

1. Look at the five circles below for a few seconds. Close both eyes and see if you can place a dot in each circle.



What does this simple test tell you about vision?

2. Observe the eye movements of your laboratory partner as he reads the introductory paragraph above. Describe the movement of his eyes.

3. Count the number of times that your laboratory partner blinks in one minute. Record your results on the chart below. Make another count for a second minute.

Students	Blinks/1st min	Blinks/2nd min
Student 1		
Student 2		
Student 3		

4. Complete the chart with data obtained by two other students.

INTERPRETATION

1. Why do your eyes blink? (Hint: See how long you can keep from blinking.)

2. How might you account for the eye movement that you observed while watching a student read?

3. Use your answer to Interpretation Item 2 to make a drawing showing what causes eye movement.

Part B

MATERIALS

Model or chart of eye

PROCEDURE

Make a diagram of an eye. Label parts as directed by your teacher.

INTERPRETATION

1. When you look at the eye of another person, which parts can you see?

2. How do you think the maker of your model found out what the internal parts of an eye look like?

3-24

MORE USES FOR SCIENTIFIC MODELS

Part A

In your study of matter you developed a scientific model. A model can be used also in the study of living things. Today you will use a model to study the operation of the lens of the eye.

MATERIALS

plastic bag	string
water	newspaper, 10 cm x 10 cm

PROCEDURE

1. Pour water into a plastic bag until it is about 2/3 full. To keep the water from spilling, use a piece of string to tie the top of the bag shut. Place the water bag on the square of newspaper, and look through the bag at the print. Describe what you see.

2. Place your hands on both sides of the water bag and slowly move them together. BE CAREFUL NOT TO BREAK THE BAG. Record any changes you observe in the appearance of the print on the newspaper.

INTERPRETATION

1. Describe the change that you made in the water bag.

2. The lens in your eye works almost the same way as the water bag. How does this help you to see?

3. What causes the lens in your eye to change shape?

Part B

Most parts of the human body are much like those of other animals. This is fortunate because it is often difficult or inconvenient to investigate parts of the human body directly. By using parts of animals as models scientists can learn many things about human structure and function.

MATERIALS

cow's eye
razor blade, single edge
dissecting tray
bank pins

PROCEDURE

1. Observe the cow's eye carefully and describe what you see. Be sure to include size, color, shape, and the names of any parts you recognize.

Before you begin Procedure 2, wait for the instructions given by your teacher.

2. Cut through the tough white outer covering of the eye. Describe what you see.

3. Which part do you think is the lens? Make a drawing of it.

INTERPRETATION

How do the parts of a cow's eye compare with the parts of a human eye? Make drawings of a cow's eye and compare it with the drawing you made in Activity 3-23.

THE SENSE OF TOUCH

Your senses tell you all you know about the world around you. Perhaps you have heard of Helen Keller, who lost her senses of sight and hearing when she was a baby. Although she still had the senses of taste and smell, most of her education was obtained through the sense of touch.

Your sense of touch comes from nerve endings that lie just below the surface of your skin. Are those nerve endings that respond to touch and pressure close together or far apart?

MATERIALS

blindfold
plastic forks, 3

PROCEDURES

1. Choose one student in your team to act as the recorder, another as the experimenter, and a third as the subject, the person who is tested.

2. Blindfold the subject.

3. The experimenter will take any one of the forks and lightly touch the subject on one of the areas shown in Chart A on the next page.

4. Ask the subject to tell the number of prongs he feels.

5. In Chart A the recorder will place a check (✓) for a correct response and an O for an incorrect response.

6. Use the 3 forks in any order and repeat the tests on each area for ten trials.

7. Record in Chart B the data gathered by another team.

CHART A: DATA FROM YOUR OWN TEAM

Trial Area	Trial Number										Number Right
	1	2	3	4	5	6	7	8	9	10	
Palm of Hand											
Tip of Index Finger											
Lower Side of Wrist											
Back of Hand											

CHART B: DATA GATHERED BY ANOTHER TEAM

Trial Area	Trial Number										Number Right
	1	2	3	4	5	6	7	8	9	10	
Palm of Hand											
Tip of Index Finger											
Lower Side of Wrist											
Back of Hand											

INTERPRETATION

1. Which of the areas tested was most sensitive to touch? What evidence do you have to support your answer?

2. Compare Charts A and B. Are there any very obvious differences or similarities?

3-26

ON YOUR OWN AGAIN

There are about 3,000,000,000 people in the world. Each is an individual with his own story. However, all human beings have many things in common. For one thing, all eat food, though not the same kinds of food. All can become tired and sick, and eventually all die. Much is being written today about the food people eat, the liquids they drink, the cigarettes they smoke, and the diseases that afflict them. During the next few weeks you are going to spend time evaluating some of the data that have been collected on these matters. This can be important to you because the decisions you are making today will affect the pattern of your life tomorrow.

Some suggestions for investigations are included in this booklet. They are grouped under three titles:

3-27:	Nutrition for Good Health
3-28:	Smoking
3-29:	Disease and Life Expectancy

Below are some suggestions for selecting and beginning your investigations.

1. Select an investigation that interests you. Read it carefully. Make sure you know the requirements and your responsibilities.

2. After you have selected an investigation, check the library and other sources for printed materials on the topic. But do not limit your resources to reading only. Contact people who are working in fields related to your investigation.

3. In many cases you will be testing and experimenting. Your observations are first-hand data that support or contradict data that you gather from reading.

4. In addition to recording data in words, you may find charts, diagrams, and graphs helpful. Photography is also an appropriate way to record scientific data.

5. Work out a schedule so that you will have your work completed by the time it is due.

6. Make a list of materials and plan to have them available when needed. Do not wait until you are going to use the equipment before checking on its availability.

7. When your investigation is complete, turn in the following items for evaluation:

   a. Data book

   b. Any charts, graphs, photographs, maps, or models that help to support your conclusions.

   c. Summary sheet containing conclusions. Conclusions should be based on the scientific processes you have used to carry out the investigation.

3-27

NUTRITION FOR GOOD HEALTH

A meal usually contains hundreds of chemically different substances. Milk alone is made up of over 125 different substances. Because your body must have many kinds of nutrients, a good diet includes a wide variety of foods.

Topics for Investigation

1. What is a balanced diet? Use several references to find out the kinds and amounts of foods a person your age should eat in order to have a balanced diet. Do your requirements differ from the needs of adults and infants? If so, how?

2. Make a collection of food labels to show kinds of substances that are added to foods. What are the purposes for adding these substances? Find out what laws regulate the adding of substances to foods.

3. Make a collection of food labels to show vitamins and minerals that are considered important in human diet. Determine if you are obtaining the minimum daily requirements of these substances. Make a chart of foods that can provide a balanced supply of vitamins and minerals.

4. Find out what you can about Mexican, French, Japanese, and Eskimo diets. Compare your findings with a recommended daily diet suitable for you.

5. Many people try to improve their health with unusual diets. Some people refuse to eat meat, some insist upon raw foods. Some people drink sauerkraut juice or live on nuts and yogurt. Such fad diets may lack essential nutrients. Too much of one kind of food may upset the digestive system. Choose one of these fad diets and determine if it provides a balanced diet. If it is balanced, name the foods that are providing the different requirements. If it is not balanced, name what is missing.

6. You have seen advertisements for commercial products that reduce acidity in the stomach. What effect do these products have on digestion? Determine what level of acidity is best for the digestion of proteins in the stomach.

7. Visit a dairy. See how milk is prepared for daily use. Report to the class about the processes used to make milk safe to drink.

8. Following are some investigations of foods that contain Vitamin C.

   a. Test some of the artificial drinks that are advertised as containing Vitamin C. Do they contain any of the vitamin? Compare each with a sample of fresh orange juice.

   b. Find out whether exposing fruit juice to air destroys Vitamin C. Use a sample of fresh juice. Test a portion immediately. Let the remainder stand in an open dish and test portions every 30 minutes. Make a graph to show the results of the test.

   c. Test the effect of heat on Vitamin C. Squeeze out a sample of fresh orange or lemon juice. Heat portions of the sample to different temperatures and re-test for Vitamin C. Plot the results on a graph.

9. The Physical Education Department of your school has many records of height, weight, and physical skills. Design an investigation that would use this data to determine growth patterns during adolescence. How does the Physical Education Department use these records?

10. Astronauts have been able to live in space for weeks. For survival many special preparations have to be made. Prepare a report showing how the needs of space travelers are provided for, how foods are prepared, the kinds of foods, how much water is provided, and how waste products are taken care of.

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3-28

SMOKING

"Caution: Cigarette Smoking May Be Hazardous to Your Health." For several years this warning has appeared on every package of cigarettes. Every day we are reminded by newspaper, magazine, television, and other sources about the hazards of cigarette smoking. In spite of all these warnings,a large number of people in the United States use tobacco,and the majority of these are cigarette smokers. Each year many young people begin to smoke. At some time you too will be faced with a decision about smoking. The following activities may help you to make your decision.

Topics for Investigation

1. Create a series of posters using cartoons, puns, or slogans about the hazards of smoking,and obtain permission to place them around the school.

2. Arrange and present a program to your classmates about the hazards of smoking. Consider using films, filmstrips, pamphlets, articles, records, etc. Discuss this program with your teacher before you contact one or more of the following for information:

   a. American Cancer Society

   b. Baltimore County Tuberculosis and Health Association

   c. Resource persons such as doctors, school nurse, science teachers, physical education teachers, etc.

3. Analyze several cigarette advertisements from magazines, newspaper, television, and radio. List the ways these advertisements lead you to believe that smoking is desirable.

4. In recent years many people have stopped smoking. Conduct a survey in your neighborhood to determine the reasons why people have stopped. Organize your data and construct a graph to show your conclusions.

5. Make a survey of adults who are still smokers to determine when they started and why, how much they smoke, why they continue to smoke, and if they feel they should stop smoking. Present your data in a suitable form. Be able to support any conclusion you make from your data.

6. A number of diseases seem to affect smokers more frequently than non-smokers. Some of these are: chronic bronchitis, emphysema, and lung cancer. Investigate and report on these diseases. Stress the characteristics of each disease and how it seems to be linked to smoking. Can you find other diseases that affect smokers more often than non-smokers?

7. Report on the history of smoking in the United States. Trace changes in kinds of smoking, in sales, and in the parts of the population that smokes.

8. Calculate the cost of smoking cigarettes in one year, ten years, and a lifetime. Use various rates of consumption such as half a pack per day, one pack per day, and two packs per day. Using the total cost from each rate, suggest another plan for spending the same amount of money.

9. Devise a smoking machine that will collect the tars produced by cigarettes. Using data from the machine, calculate the amount of tars that would accumulate in the lungs in one year if a person smoked a pack of cigarettes a day.

10. With your smoking machine, compare the amount of tars produced by different brands of cigarettes. Compare your findings with surveys and claims made by the manufacturers of those brands of cigarettes.

11. Cigarette manufacturers claim that filters decrease the amount of tars produced by their cigarettes. With the smoking machine, compare the various filters, arranging the kinds of filters from least to most effective.

12. Use the smoking machine to obtain data on the tars produced by cigars and pipes. How do these tars compare in such characteristics as amounts, color, consistency, etc., to tars produced by cigarettes? Is it safer to smoke cigars and pipes rather than cigarettes? Support your conclusion.

13. Observe the effect of different kinds of smoke on insect activity. Suggested sources of smoke are paper, wood, cigar, pipe, and cigarette. Describe your investigation and be prepared to support your conclusions.

14. One of the substances in tobacco smoke is nicotine. Report on the following aspects of this substance: chemical classification, effects on body, sources, amount per each tobacco source, and commercial uses.

15. Many smokers claim they want to stop smoking but cannot. In order to help these people, ways have been devised to make the use of tobacco less damaging. List and describe the items that have been invented or produced to reduce the dangerous effects of tobacco. Can you invent some devices of your own ?

16. Report on the operation and results of smoking-withdrawal clinics. If one is in your community, ask permission to attend a meeting. Find how the treatment varies depending on the personalities of each smoker.

17. List arguments used in defense of cigarette smoking. For each argument provide facts that either support or fail to support it.

18. Describe public health procedures for curtailing or reducing smoking. Discuss the pros and cons of each. You may also suggest additional procedures.

19. Set up a panel discussion on "Why People Smoke." The panel may be composed of classmates or resource people or a combination. Check with your teacher before selecting the panel.

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3-29

DISEASE AND LIFE EXPECTANCY

Some purposes of learning about the proper care of the body are: to avoid disease, to prolong life, and to make life more pleasant. A study of disease and life expectancy can provide us with information that will help achieve these purposes.

This investigation is designed to enable you to get some answers to the following questions:

1. How has life expectancy changed over the years? Another way to state this question is: Can you expect to live longer than your parents and grandparents?

2. How are rates of death from disease related to life expectancy?

3. How has the pattern of fatal diseases changed over the years? Are the diseases that kill people today different from the ones that killed people in former years? What kinds of diseases must we guard against today?

To answer these questions you must collect data and devise a way to display and analyze the data. Include:

1. Life expectancy, past and present

2. Death rates from all causes, past and present

3. Death rates from each of the main types of disease--infectious and non-infectious

Find a way to compare the data from the three categories above. Draw some reasonable conclusions from the comparison. The conclusions should be answers to the questions listed above. If you have difficulty finding data or devising ways to display the data,ask your teacher for help. But remember that this is meant to be an independent investigation, so you should do as much on your own as possible.

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BALTIMORE COUNTY PUBLIC SCHOOLS

TEACHERS' MANUAL

Junior High School Science, Grade Seven

A SEARCH FOR STRUCTURE

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FOREWORD

As part of a continuing effort to upgrade science teaching in the Baltimore County Schools, the 1968 and 1969 Summer Workshop Committees have produced a new science program for Grade Seven. A description of the way in which the program was developed is found in the first part of this bulletin.

In describing the procedures that were followed, the Workshop Committees have indicated their indebtedness to numerous individuals and groups. In addition, the Office of Science wishes to express deep-felt appreciation to the following people:

> To the members of the two Workshop Committees, who worked diligently, creatively, and cooperatively to design and produce an outstanding science program for seventh-grade students;
>
> To the pilot teachers and to all other science teachers who made substantial contributions to the project;
>
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August 5, 1969

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THE DEVELOPMENT OF A JUNIOR HIGH SCHOOL SCIENCE PROGRAM

Revision of a science program is a continuous process. It goes on in every teacher's classroom every day. Periodically, however, there is an organized effort to develop a curriculum, taking advantage of the latest developments in the philosophy, processes, and products of the scientific endeavor as well as developments in learning theory and pedagogy.

The first major effort to develop a junior high school science curriculum for the Baltimore County Public Schools was made in 1946-1948, when the junior high school, as such, became part of the County's organizational pattern. This program served the teachers and students well for ten years, albeit it evolved and improved as individual teachers lent their special creativity to its implementation. A second major effort resulted in the 1958 program. It too, served the County for a decade; but, as before, evolved and developed in the hands of the classroom teachers.

With the advent of nation-wide curriculum projects and the almost unanimous agreement among science educators that the program in junior high school science should be truly investigative, there was a need for a third restructuring of the program in Baltimore County. A beginning was made with the introduction, on a pilot basis, of programs designed by the national curriculum groups. Approximately 75 teachers have worked for one or more years with seven major programs: 1) Earth Science Curriculum Project, 2) Interaction of Matter and Energy, 3) Intermediate Science Curriculum, 4) Investigating Matter and Energy, 5) Introductory Physical Science, 6) Time, Space, and Matter, and 7) The University of Illinois Astronomy Units. Many of these teachers attended institutes and briefing sessions prior to teaching the programs, and throughout the two years of pilot use there were County-wide meetings of the teachers for each program.

A preliminary Junior High School Science Workshop, held in 1966, recognized the shifting of emphasis away from demonstration teaching, with limited student participation, towards a student-centered investigative approach. The teachers in this workshop prepared a series of student laboratory investigations based on the existing Course of Study. These were distributed to all junior high school science teachers for use with their classes in 1966-1968. They served also as a "seeding" operation to stimulate individual teachers and, in some instances, groups of teachers to design additional investigations. The goals for each of the laboratory investigations prepared by the 1966 Summer Workshop were stated in behavioral terms, using the verbs developed for the AAAS elementary science program, Science: A Process Approach. Sample activities to appraise the change in student behavior produced by the investigations were also developed.

The experience gained from both the pilot teaching of the nationwide programs and the use of the County's laboratory investigations provided the background for planning a full-scale summer workshop in 1968 to develop a new junior high school curriculum.

Setting the Stage

Specific plans for the 1968 Junior High School Science Workshop were initiated with the appointment of a Steering Committee in the fall of 1967. The members of this committee included Max Berzofsky, Loch Raven Junior High School; Robert McNeish, Arbutus Junior High School; Joseph Oursler, Old Court Junior High School; Carroll Parker, Ridgely Junior High School; Grady Prater, Towsontown Junior High School; and members of the Office of Science.

Meeting in fourteen sessions during 1967-1968, the Steering Committee planned a course of action. Highlights of the committee's activities include:

1. Observations and discussions of the nation-wide junior high school science programs taught at the pilot centers
2. Preparation of a questionnaire, "The Junior High School Science Program, A Survey of Opinion" and its distribution to every secondary school science teacher in Baltimore County and to leading science educators throughout the country
3. An in-depth study of all new science textbooks and references
4. Planning of five area meetings for science department chairmen and principals so that every school could have an opportunity to express points of view in small group discussions
5. Preparation of a bibliography of the most recent publications on science education
6. Presentation to science department chairmen of the new elementary school science programs
7. Visits to selected junior high schools by the Science Specialist to sample opinion about the kind of program teachers wanted

8. Acceptance of "The Conceptual Schemes of Science"[1] and "Characteristics of a Scientifically Literate Person"[1] as guidelines for the development of the junior high school science curriculum

9. Consideration of the pros and cons of various types of organizational patterns for a science curriculum, including adopting a textbook series, using national programs, and developing a block approach

10. Development of a set of sixteen Working Hypotheses for the junior high school science curriculum[2]

The curriculum materials for Grades 7 through 9, written in the summer of 1968, were tried in a number of pilot schools during the school year 1968-1969. Teachers using these materials provided feedback in the form of evaluation sheets for each student activity. They also participated in a series of evaluation sessions. Some feedback was obtained from students, as well.

The Steering Committee continued to meet after school and evenings to evaluate the experience of the pilot schools and to refine plans for the 1969 summer workshop. Most of the members also attended two special statewide workshops on behavioral objectives and learning hierarchies held at the University of Maryland and the Tidewater Inn at Easton, Maryland. It was decided that energy in the 1969 Workshop could best be expended by a thorough revision of the seventh grade curriculum with a view toward:

1. Enlargement of the scope of material covered
2. Development of a learning hierarchy
3. Refinement of behavioral objectives and their attendant assessment tasks.

Only minor revisions, based on the teacher evaluation sheets, were to be made in the eighth and ninth grades.

Goals of Science Teaching

One of the working hypotheses states that, in a junior high school science curriculum, there should be a balance among the three types of goals: processes, concepts, and values. In planning and developing the program consideration was given to each type of goal. The greatest emphasis was placed on the tools of the scientist or the processes of scientific investigation, including observing, classifying, measuring, inferring, predicting, interpreting, hypothesizing, and the like. The primary objective of Phase One of the Seventh Grade Program is the development of scientific processes and skills. The students begin with the process of observation, in which they learn to distinguish between things that can be observed and those that cannot be observed. They find out that what an observer sees depends upon the viewer's position and the limits of the instruments he uses. In addition to the processes, the students are taught operational skills as they develop tools for determining volume, mass, and density. Concepts are developed concurrently with the processes and values are interwoven where appropriate.

---

[1] Guidelines and Strategies for Science Curriculum Development, Second Draft, January 1968. pp. 33-35

[2] See Appendix A.

The processes involved in the process approach to teaching science fall into three major groups--the processes involving the collection of data; processes involving interpretation and inferences made from this data; and processes involving the application of what has been learned. Within each area the processes move from the simple to the complex as the areas themselves progress from the concrete to the abstract. Though each is important within itself, the success of the approach hinges upon the interdependence of all processes.

Skills are also an integral part of the process approach to teaching science. To insure the success of the approach they must be developed simultaneously with the processes. They cannot be taught separately and must progress from the simple to the complex. Continual repetition and reinforcement of skills is necessary if they are to become useful tools within the processes. Examples of processes and skills are listed below in outline form.[3]

I. Processes :

A. Processes Involving the Collection of Data

1. Observation is probably the simplest process used in this area.

a. Superficial observation is merely the description of an object such as a mineral, insect, or other piece of matter.

---

[3] Adapted from Brown, Walter R. "Defining the Processes of Science: A Statement by Educators in India." The Science Teacher, Vol. 9, December 1968, pp. 26-28.

b. More detailed observation leads to a description of the properties of an object such as density, hardness, or metabolism.

c. Complex observation involves a description of changes such as erosion, growth, or changes in the states of matter.

2. Classification or the grouping of things according to common or similar characteristics is another process important in collecting data.

a. An example of a simple classification is grouping according to state of matter.

b. A more complex classification is the grouping involved in the construction of a periodic table.

B. Processes Involving Interpretation and Inferences

1. Interpretation is an area involving the organization and analysis of data so that a hypothesis may be verified or a relationship discovered.

2. The simplest form of interpretation is made when data are organized into either tabular or graphic form so that trends and relationships can be more easily identified.

3. A more complex form of interpretation is the development of operational or working definitions.

4. The final stage of this process involves the formulation of conclusions from collected data.

C. Processes Involving the Application of What Has Been Learned

1. Application is the process of evaluating and extending interpretations arrived at earlier.

2. It involves using observations and interpretations to predict, generalize, and further hypothesize.

II. Skills

A. Use of all the senses to provide objective, detailed observation

B. Use and operation of common measuring devices

C. Recording of data by means of charts, tables, and graphs

D. Construction and interpretation of graphs

E. Use of computational devices such as scientific notation, decimals, per cent, fractions, ratios, and average

F. Determination of the sources of error and the size and correction of errors

G. Selection and identification of the materials needed to solve a particular problem

H. Use of dimensions and units

Process objectives have been listed in the Teachers' Manual for each of the student investigations. They may be used both as a guide for teaching and as a means of evaluating student progress. Similarly, the concept goals are listed for each student investigation.

In order to answer the question, "What knowledge and skills should be taught at the junior high school level?" the Junior High School Workshop Committee agreed to accept "The Conceptual Schemes of Science"[4] as developed by the NSTA Curriculum Committee. These major conceptual threads or themes served as guidelines for the planning of the science curriculum. They contain six statements dealing with the nature of science and eight statements dealing with the nature of matter.

The conceptual theme for Grade Seven is structure and, accordingly, the course itself is entitled "A Search for Structure." Change is the focus in the eighth grade program, which is called "The Changing World." Interaction is the conceptual theme and title of the ninth grade program. The remaining five themes, which deal with classification, probability, equilibrium, motion, and living things are incorporated in varying degrees at all three grade levels.

According to Bloom's Taxonomy,[5] there are three domains of educational objectives: 1) the cognitive domain including objectives dealing with recall or recognition of knowledge and the development of intellectual abilities and skills, 2) the affective domain describing changes in interest, attitude, and values, and the development of of appreciations and adequate adjustments; and 3) the psychomotor domain dealing with objectives that emphasize some muscular or motor skills. It is within the affective domain that the values for science education can be found. Many of these values are listed in the "Characteristics of a Scientifically Literate Person."[6]

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[4] See Appendix B.

[5] Krathwohl, David R.; Bloom, Benjamin S.; and Masia, Bertram B. Taxonomy of Educational Objectives. New York: David McKay Co., Inc. 1964. p. 6

Value goals should be an integral part of education. Although the writing team kept these goals in mind as they developed the student investigations, they did not list them specifically in the Teachers' Manual as they did the processes and concepts. Individual teachers must identify relevant and meaningful values for the students whom they teach. The "Summary Report of NSSA-NSTA Workshops on Behavioral Objectives"[7] will serve as an excellent reference for this task. One of the behavioral descriptions in this document states, "The student recognizes that the achievements of science and technology, properly used, are basic to the advancement of human welfare." Two specific behaviors listed under this heading are: " Supports taxes for community solution of pollution problems" and "Does not pollute air and streams, and practices conservation." This kind of analysis should be a natural outgrowth of the student activities and class discussions.

Behavioral Objectives

One or more behavioral objectives has been stated in the teacher manual for each student activity. What are behavioral objectives?

It has been the practice of educators to establish objectives for all phases of curriculum work: broad, general objectives (usually called goals) for entire curricula, somewhat more narrow objectives for various phases, and specific objectives for individual lessons. The avowed purpose was to provide orientation and direction to the teaching process. Most of such objectives were stated in terms of the student, as they should be, and took a form such as: "The students should acquire an appreciation of the acuteness of their sense organs." Admittedly this objective is desirable and important but how can the teacher evaluate the extent of a student's "appreciation" of an idea?

In recent years educators have evolved the idea of stating goals in behavioral terms and have agreed to call them behavioral objectives. Simply, behavioral objectives are objectives stated in terms that permit a teacher to evaluate student achievement of them. The evaluation is based upon observable behavior of the student. Behavioral objectives request students to demonstrate behavior by carrying out certain actions, such as: identifying , naming, constructing, demonstrating, describing, ordering, stating a rule, and applying a rule.[8] Reexamine the example in the previous paragraph where the objective was to acquire an appreciation of the acuteness of our sense organs. A careful analysis of that objective shows that it contains units that we can evaluate. If the student is requested to: "DEMONSTRATE that both ears can locate a sound more exactly than one ear," the student now has the opportunity to indicate that he understands the objective. The teacher can specifically deduce from the students' behavior that understanding has occurred. In other words, behavioral objectives state specifically what a student should be able to do after he completes a given learning activity. The teacher, in turn, should be able to observe the students' behavior to assess competencies.

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[6] See Appendix C.

[7] See Appendix D.

Learning Hierarchies

Teachers with a philosophical turn of mind may object that behavioral objectives can deal only with rather trivial kinds of goals. But, just as a building is composed of individual bricks so a learning structure can be developed by the proper choice and sequence of behavioral objectives. Such a learning structure is referred to as a Learning Hierarchy.

Any arrangement in successive groups according to rank can be called a hierarchy. Learning hierarchies are formulated around behavioral objectives. Each behavioral objective is associated with one or more exercises. A written behavioral objective is a statement (using an action verb) that describes what the learner is expected to exhibit as he performs the learning activity. The objective should describe the purpose or expected outcome of the instruction. The characteristics of behavioral objectives should include six components:

1. Who is to exhibit the behavior?
2. What observable action is the learner expected to exhibit?
3. What conditions, objects, and information are given?
4. Who or what initiates the learner's performance?
5. What responses are acceptable?
6. What special restrictions are there on the acceptable response?

When behavioral objectives are arranged in an increasing order of complexity, a learning hierarchy results. A learning hierarchy consists of a terminal behavior, its identified subordinate behaviors, and the learning dependencies among these behaviors.

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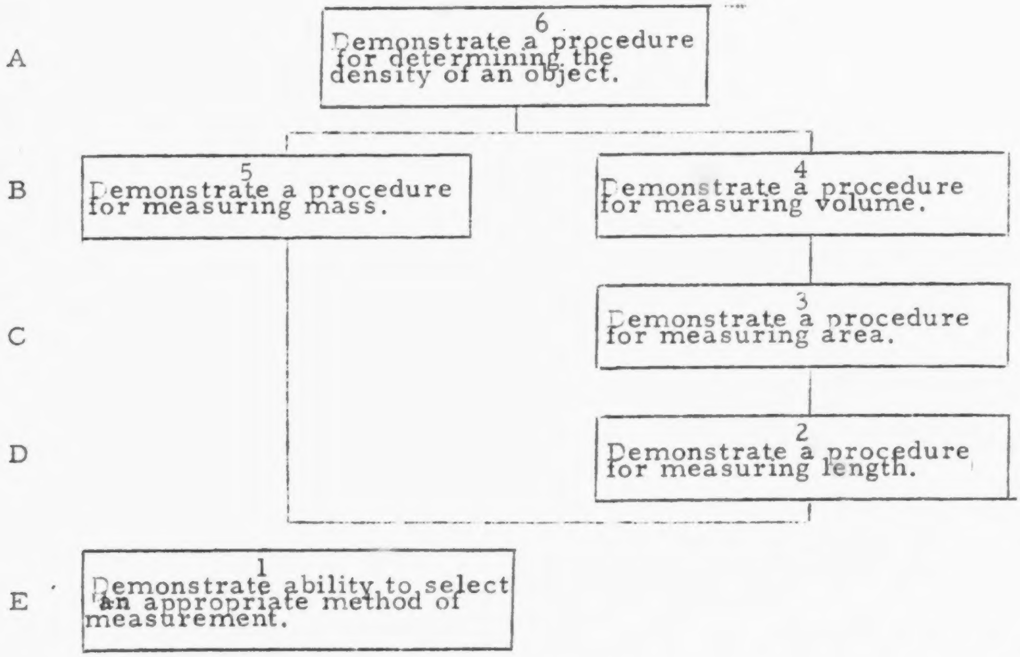
[8] See Appendix E.

In a learning hierarchy the most complex behavior is the terminal behavior. A terminal behavior is the behavior the learner is expected to be able to exhibit after some specified instruction and for which there are one or more behaviors the learner must acquire as prerequisites. A terminal behavior might be one that is reached after a year's instruction or after one day of instruction. When identified, each terminal behavior can be analyzed in terms of needed subordinate behaviors. Subordinate behaviors are defined as those behaviors needed in order to attain the terminal behavior. A terminal behavior and its set of immediately subordinate behaviors are called a learning dependency. A collection of one or more learning dependencies is called a learning hierarchy.

For a hierarchy to be valid every learning dependency is examined in terms of the following two hypotheses:

1. If the student has acquired the terminal behavior then he will also have acquired all the subordinate behaviors.
2. If the student has acquired all the subordinate behaviors then he will also have acquired the terminal behavior, assuming he has been exposed to the intended instruction.

An example of a learning hierarchy is shown below.


A
B
C
D
E
6 Demonstrate a procedure for determining the density of an object.
5 Demonstrate a procedure for measuring mass.
4 Demonstrate a procedure for measuring volume.
3 Demonstrate a procedure for measuring area.
2 Demonstrate a procedure for measuring length.
1 Demonstrate ability to select an appropriate method of measurement.

In this example the levels of complexity are listed in the left-hand column with the most complex level labeled A. Each block contains an objective to be achieved. The following system can be used to describe the learning dependencies.

Terminal Behavior	Immediate Subordinate Behavior
6	5, 4
5	1
4	3
3	2
2	1

Assessment Tasks

In order to provide the teacher with some means to evaluate student progress in attaining a given behavioral objective the "Assessment Task" was developed. An assessment task should match the desired behavior and the response to it should itself be observable. The sample assessment tasks included in the Teaching Suggestions are based upon the corresponding behavioral objectives. They are an attempt to show one way of evaluating student acquisition of the behaviors called for by the objectives. Some assessment tasks require students to display their competencies through interaction with objects; other tasks may be of the pencil and paper variety. Both types will be found in the samples. Indeed, each activity may be thought of as a kind of assessment task and the teacher will undoubtedly develop his own methods for evaluating students' performance in the laboratory.

OVERVIEW TO PHASE ONE

The primary purpose of Phase One of the seventh grade program is to develop processes and skills that students will find useful in their further study of science, in their other studies, and in out-of-school living as well. These processes and skills are summarized as the objectives that appear in the Appendix of the Student Manual. They have been stated in behavioral terms, using the verbs developed by Walbesser for the AAAS program, "Science, A Process Approach." For students, the processes and skills are arranged in sequence from the simplest, "Identify the appropriate sense needed to make an observation," to the most complex, "Construct an investigation and demonstrate the procedures to test an idea."

Another way to look at these objectives is to arrange them in a learning hierarchy, as described on Pages 9-10. In this kind of arrangement, the terminal objective for the entire Phase One and its relationship to the other objectives are shown graphically as a set of learning dependencies. Within the total hierarchy, there are sets of minor terminal objectives, each with its subordinates. Each set is in itself a learning dependency.

Processes are the very heart of science. But they cannot be developed in a vacuum, they cannot be developed without concern for content. Any of a variety of content topics may be employed as a vehicle for developing the process hierarchy. Two different approaches have been worked out in detail for Phase One: Option A, Rocks and Minerals, and Option B, Insects. Teachers may select one or the other approach, or they may have their students make the choice. If, after teaching one of the options, the teacher feels that further reinforcement of the processes and skills is needed for some or all of his classes, he may elect to repeat Phase One using the other option. Particularly ambitious teachers may even work out a set of activities using some entirely different content approach.

The hierarchy for Option A is given on Page 15, the hierarchy for Option B on Page 19. The process objectives, numbered to match the numerals in the hierarchy, are given on Pages 13-14 , and Pages 17-18 , respectively. Thus the teacher can find the position of each objective on the hierarchy chart. In addition, the same numbering system has been used in listing objectives for each student investigation.

Option A. Rocks and Minerals

Option A makes use of the study of rocks and minerals as a vehicle to develop processes and skills fundamental to further student work in Grade Seven. It is not required that the teacher have any special knowledge of rocks and minerals, since accurate identification is not a goal of the work. As a final task the student does attempt to name minerals, but this is done only on the basis of his own observations compared to mineral characteristics in the mineral Identification Chart.

The learning hierarchy for Option A develops four major skills: observation, measurement, charting and graphing data, and the formulation of hypotheses based upon evidence. The first three investigations help the student distinguish between observation, which is impression from one of the senses, and non-observation or inference, which is a product of thought processes.

From these investigations the student develops behaviors appropriate to Process Objectives 1 and 2 in the learning hierarchy. Because Objectives 1 and 2 are at the same approximate level of learning difficulty, they are arranged parallel to each other in the hierarchy chart.

Many of the observations made by students in the first three investigations center around the possible exploration of a body in space called "Planet G." This idea is developed further in the next four investigations (1A-4 through 1A-7) as students observe samples from the surface of Planet G (obviously Gaea, the earth) and extend their observations of various rock and mineral samples through the use of simple instruments. These investigations help students to name the qualitative characteristics of the samples and to distinguish among them on the basis of observable characteristics. By this time Objectives 3 and 4 have been reached and Objectives 5 and 6 have been introduced.

In 1A-7 students begin a rock collection, which will be useful in 1A-10 and 1A-29 where students attempt to name minerals in rocks - at first on the basis of qualitative characteristics, and then later on the basis of both qualitative and quantitative properties.

In 1A-11 the students discover another property of rocks and minerals, one for which he must learn some quantitative methods. In order to measure the specific gravity of a rock or mineral, students must first gain some knowledge of the measurement of volume, mass, and weight. The hierarchy objectives that deal specifically with skills in measurement are developed in 1A-12 through 1A-19.

Investigations 1A-20 and 1A-21 reinforce all previous behaviors and develop Objective 13, in which the students describe qualitative and quantitative characteristics of minerals.

Beginning with 1A-22 students use their measurement skills to distinguish among rocks and minerals on the basis of density and specific gravity. During their investigations leading toward the concept of density, students acquire skills in charting and graphing data. For this reason, the hierarchy chart, beginning with Objectives 14 and

16, separates into two sets. The set of objectives beginning with 14 is used to develop the concept of specific gravity, while the set of objectives beginning at 16 develops skills in charting and graphing.

In 1A-27 and 1A-28 the students examine data critically for the purposes of identifying those that support an idea and of deciding whether an idea is supported by given data. In 1A-28 the students make careful qualitative and quantitative observations of a set of minerals and attempt to name the minerals on the basis of evidence gathered.

Finally in 1A-29 students reach Objective 27. They are asked to formulate hypotheses about names of minerals in rocks. To do this, students spend two or more class periods independently investigating rocks, using all of the skills they have acquired throughout the course.

When Phase 1A is completed, each student should have acquired all of the basic processes needed to pursue the work in Phases 2 and 3.

Objectives. Rocks and Minerals

1. Identify the appropriate sense needed to make an observation.
2. Distinguish between an observation and non-observation.
3. Name the qualitative characteristics of objects, using one or more of the senses.
4. Distinguish among objects on the basis of observable characteristics.
5. Demonstrate the ability to use instruments in making observations.
6. Demonstrate the ability to select the proper instrument to extend observations of qualitative characteristics.
7. Distinguish between qualitative and quantitative characteristics of objects.
8. Demonstrate a procedure for using the metric system to determine length.
9. Demonstrate a procedure for measuring area.
10. Demonstrate a procedure for measuring volume.
11. Demonstrate a procedure for measuring mass.
12. Demonstrate the ability to select the appropriate instrument to measure the quantitative characteristics of objects.
13. Describe qualitative and quantitative characteristics of objects.
14. Distinguish among objects on the basis of density and specific gravity.

15. Distinguish among objects on the basis of physical properties.

16. Construct a chart of paired measurements.

17. Construct a chart of paired measurements after first ordering one of the sets of measurements.

18. Distinguish the dependent variable from the independent variable, given a chart of paired measurements with one of the sets of data ordered.

19. Apply the rule that the scale for the independent variable is ordered on the horizontal axis of a graph and the scale for the dependent variable is ordered on the vertical axis.

20. Identify a point on a graph, given a pair of measurements.

21. Construct a line graph of ordered pairs.

22. Construct a statement that describes a set of data.

23. Construct one or more ideas from a table and a graph.

24. Construct one or more ideas from a set of observations.

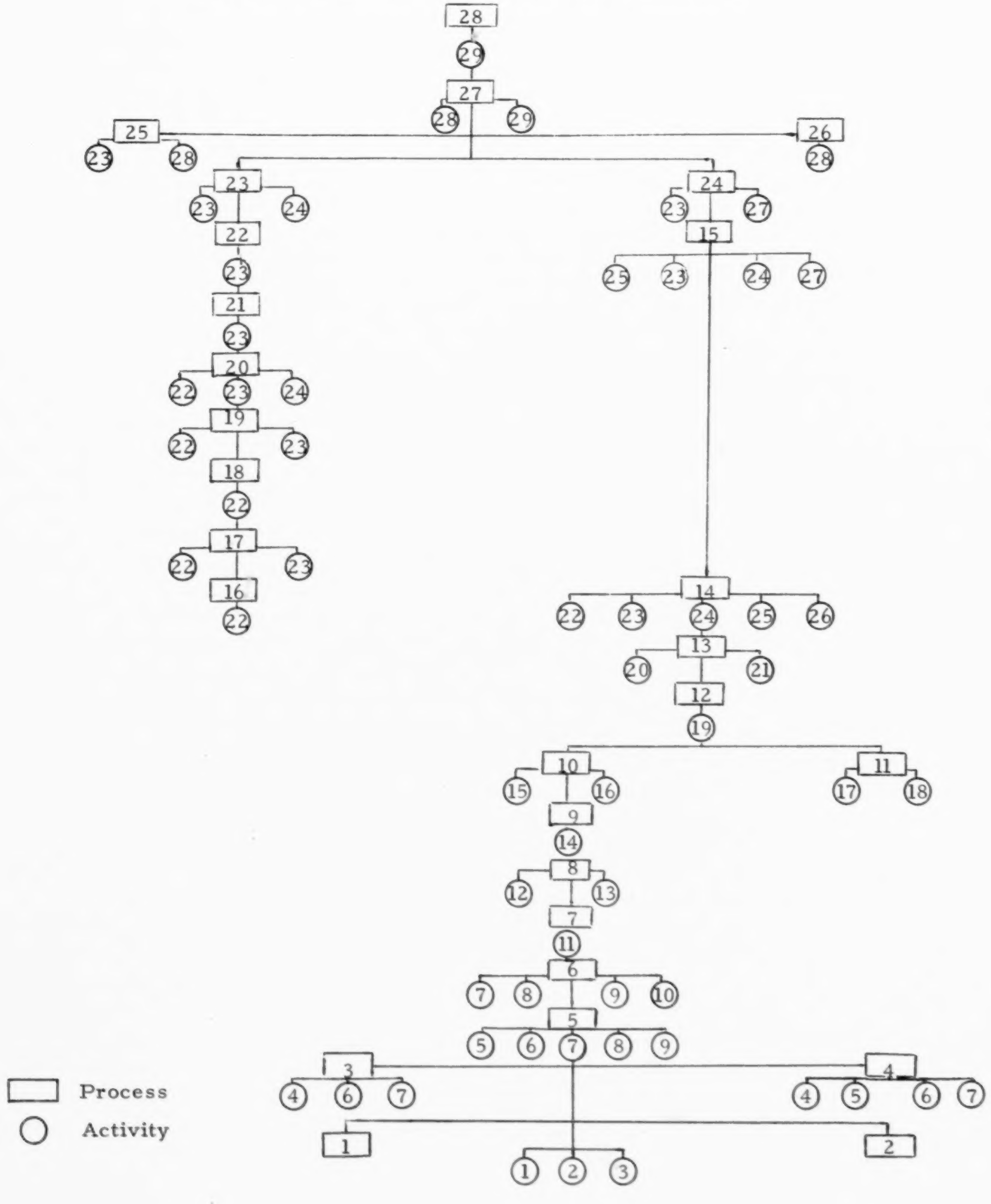
25. Identify the data that supports an idea.

26. Distinguish whether or not an idea is supported.

27. Order a set of ideas from least to most probable.

28. Construct an investigation and demonstrate the procedures to test an idea.

PROCESS HIERARCHY: ROCKS AND MINERALS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Process
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Option B. Insects

Option B begins with observation, the least complex of the processes. In 1B-1 the students observe various diagrams and objects and record their observations. From discussion the students should realize that they are using their senses to make observations. Additional practice in observation follows in 1B-2 and 1B-3. All three investigations help the students to distinguish between an observation and a non-observation. The first two objectives are on the same level of the hierarchy. This indicates that neither is prerequisite to the other and they may be developed simultaneously.

Beginning with the second investigation, most of the study is related to insects. However, the intent is not an in-depth study of insects, but rather insects constitute a vehicle through which process objectives are reached. Students first observe preserved crickets, followed by various live insects and, finally, grasshoppers. These activities are all centered around the third process objective, 'Name the qualitative characteristics of objects, using one or more of the senses.' Concurrently with the process development, the students learn the characteristics by which insect may be distinguished from other animals.

Now the students can begin their own insect collections, which will be used to develop some of the later processes. The insect collections not only reinforce the work on observation but also show a need for instrumentation, as students realize the need to extend their senses to make better observations. In 1B-8 through 1B-12 skills of using a hand-lens, a microscope, and a stereomicroscope are developed. This portion of the study teaches Objectives 5 through 9 in the hierarchy.

Next students become aware of the need to make quantitative as well as qualitative observations. Instruction in linear, time, and temperature measurements are provided in 1B-13 through 1B-15. From the data collected, the students learn to compute averages. At this point, the students select and use an appropriate instrument to extend their observations. To complete the work on observations of quantitative characteristics, 1B-17 and 1B-18 provide instruction in the measurement of the volumes of regularly and irregularly shaped objects.

In addition to the work on volume, students are required to use balances to measure mass in preparing culture medium for fruit flies. "Rearing Fruit Flies," 1B-20, provides an opportunity to reinforce many of the prior process objectives. In addition, it supplies to students a rationale for the development of the processes.

In 1B-21 the data relates to insect study but the processes deal with collecting and graphing data. From studies concerning crickets and

and fruit flies students construct and analyze charts, tables, and graphs. Process objectives 18 through 20 in the hierarchy are covered covered in this activity.

Investigations 22 through 24 deal further with the interpretation of graphs, tables, and charts. Objective 21 is developed in the same activity as 22 and 23, but in the hierarchy it is placed below the latter two because it is a simpler process. On the other hand 22 and 23 are found on the same level of the hierarchy because they are developed at the same time and are of about equal difficulty.

Once a hypothesis is formulated, the next step is to establish whether or not it is supported by data. This is Objective 24 and it is developed in 1B-25.

To prepare students for constructing their own investigation, they are given the opportunity to order a list of ideas in terms of probability and to justify their results on the basis of evidence provided. These skills (Objectives 25 and 26) are developed in 1B-26 and 1B-27.

The terminal objective of Phase One is to construct an investigation and demonstrate the procedures to test an idea. In Option B, this objective is developed in 1B-28 and 1B-29 in two ways: by constructing an experiment with fruit flies, and by identifying and ordering student insect collections.

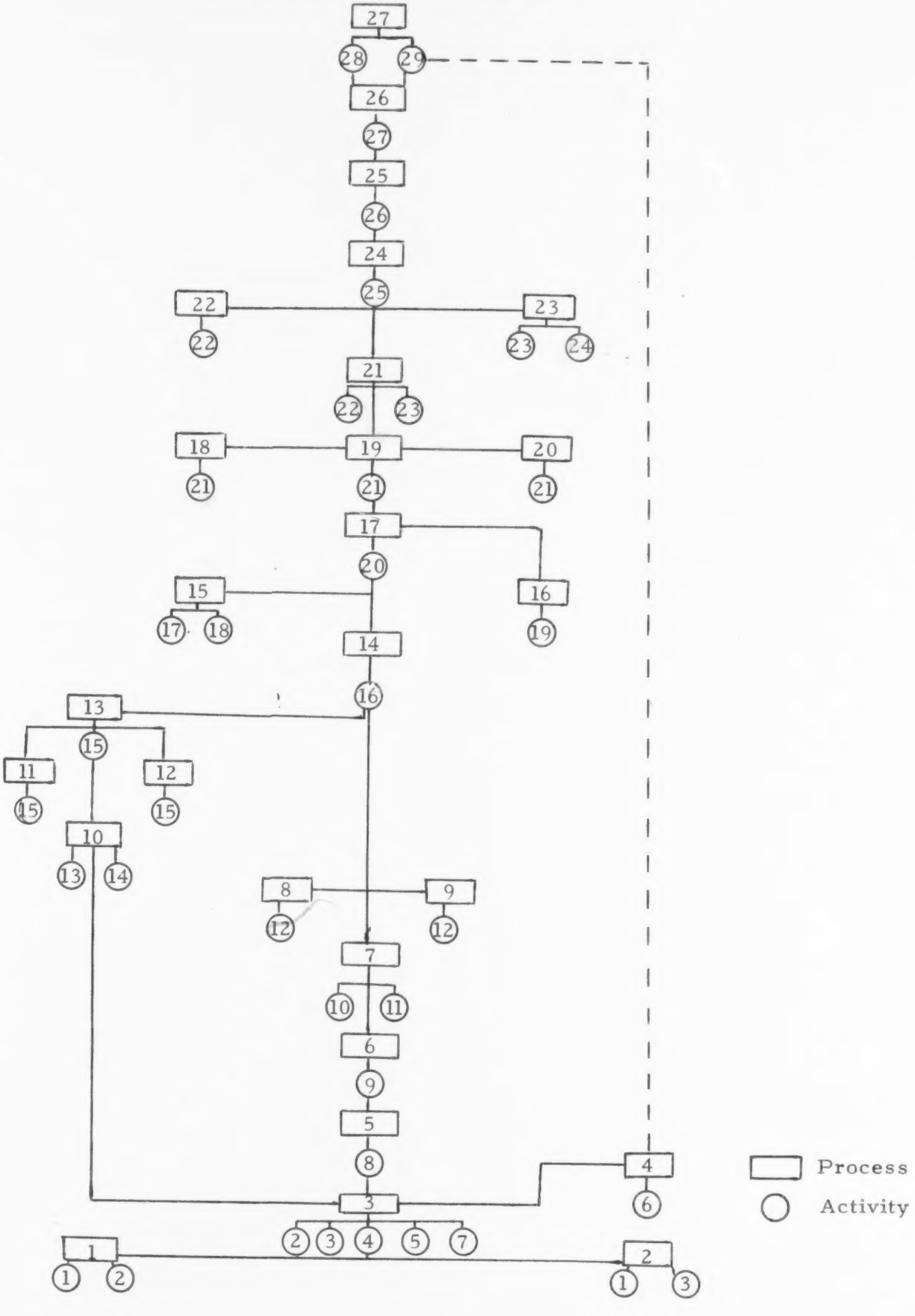
Throughout Phase One, the teacher should feel free to enrich the students' science experiences. Audiovisual materials, teacher demonstrations, and other activities can be used. The entire curriculum guide was designed to help both teacher and student; it was not intended to be constraining. Teachers and students, working together, may pursue their own interests in any of the phases.

Objectives. Insects

1. Identify the appropriate sense needed to make an observation.
2. Distinguish between an observation and a non-observation.
3. Name the qualitative characteristics of objects, using one or more of the senses.
4. Demonstrate the ability to locate, collect, and preserve insects.
5. Demonstrate the use of a hand lens.
6. Identify and describe the functions of the main parts of a microscope.
7. Demonstrate the proper use, care, and handling of a microscope.

8. Identify and describe the functions of the main parts of a stereomicroscope.
9. Demonstrate the proper use, care, and handling of a stereomicroscope.
10. Demonstrate a procedure for measuring length.
11. Demonstrate a procedure for measuring time.
12. Demonstrate the ability to read a thermometer.
13. Demonstrate the ability to find an average.
14. Demonstrate the ability to select and use an appropriate instrument to extend observations.
15. Demonstrate a procedure for measuring volume.
16. Deomonstrate a procedure for measuring mass.
17. Demonstrate a procedure for culturing fruit flies.
18. Construct a chart of paired measurements.
19. Construct a chart of paired measurements after first ordering one of the sets of measurements.
20. Distinguish the dependent variable from the independent variable, given a chart of paired measurements with one of the sets of data ordered.
21. Construct a line graph from a table of data.
22. Construct one or more ideas from a set of observations.
23. Construct one or more ideas from a table or graph.
24. Identify the data that supports an idea.
25. Order a list of ideas from least to most probable.
26. Distinguish whether or not an idea is supported.
27. Construct an investigation and demonstrate the procedures to test an idea.

PROCESS HIERARCHY: INSECTS



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Process
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IA-1

OBSERVATION

OBJECTIVES

Processes

1. Identify the appropriate sense needed to make an observation.

2. Distinguish between an observation and a non-observation.

REFERENCE

Earth Sciences Curriculum Project. Investigating the Earth. Teacher's Guide. pp. 20-22

TEACHING SUGGESTIONS

Preparation[1]

Construct four sets of the five boxes described below.

Box 1. Label as follows: Station No. 1 - DO NOT TOUCH THIS BOX. Look at the objects inside the box. Observe and describe as many properties of these objects as you can.

Construction: Place 3 or 4 solid objects (of rock, clay, metal, or plaster) and a vial of fluid in a shoe box. Replace lid with transparent cellophane and tape securely.

Box 2. Label as follows: Station No. 2 - DO NOT LIFT THIS BOX, REMOVE THE LID, OR LOOK INSIDE. Reach inside the box through the opening at the end. From the feel of the materials, describe characteristics of the objects in the box.

Construction: Fill each of three small cloth bags with a different substance. The substance should differ in particle size; for example, cornmeal, sand, and BB shot. Place the bags in a shoe box. Replace the end of the box with cloth curtains.

Box 3. Label as follows: Station No. 3 - DO NOT REMOVE THE LID FROM THIS BOX. You may lift, gently shake, or tip this box to observe the properties of the object or objects inside.

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[1] Adapted from ESCP. Investigating the Earth, Teacher's Guide, pp. 20-22

Construction: Place one each of several familiar objects (for example, a marble, sponge, nail, paper clip) in a shoe box. Tape shut the lid of the box. Leave contents loose in box.

Box 4. Label as follows: Station No. 4 - DO NOT LIFT THIS BOX OR REMOVE THE LID. Poke the wooden rod straight down through any 10 holes to determine the properties of the object or objects in the box.

Construction: Place one hand-size rock or an irregularly-shaped plaster model into a shoe box. Using a cork-borer having a diameter slightly larger than a dowel stick, cut a grid of at least 25 holes in the lid of a shoe box. Tape the lid to the box. Provide a dowel stick for each box.

Box 5. Label as follows: Station No. 5 - YOU MAY TOUCH, SMELL, LIFT, OR EXAMINE THE MATERIAL IN THIS BOX IN ANY WAY THAT WILL HELP YOU DETERMINE ITS PROPERTIES.

Construction: Just before each class place into a shoe-box a puddle of freshly mixed plaster or a mass of "Play-doh." Discard the lid of the box.

Procedure

Set up five stations. At each station place four identical boxes. Divide the class into pairs of students and assign four pairs to each station. Show the students how to move from station to station at a stated signal. Allow about three minutes at each station. Because this may be for some students the first experience in this type of investigation, circulate while they are working and give help where needed.

Expected Results

After the investigation discuss the observations made at each station and list them on the chalkboard. Emphasize the following:

Station 1. Almost all observations are based, at least in part, on sight.

Stations 2 and 3. Most observations made by human beings are visual. Relatively little information is obtained through other senses.

Station 4. The probe extends the observer's sense of touch. It is important that students recognize the connection between the number of probes or samples taken and the extent to which their conclusions approximate reality. For example, have students compare the amount of knowledge they would have about the shape of the hidden object if they were allowed only three probes instead of ten.

Station 5. Some substances, objects, and phenomena change during the time in which observations are being made. If freshly mixed plaster is used, the first observers find that the material is soft; later observers discover that it is hard. Both descriptions are correct, depending on the time of the observation.

As a summary of the discussion, bring out the following:

1. the distinction between observation and non-observation
2. the significance of variety among the characteristics observed by different students at the same time
3. methods to improve observation

Assessment Task

For each quality on the left, identify from the list on the right the sense used to observe it.

(E) color of a ball

(A) loudness of a voice

(D) roughness of a stone

(C) odor of a rose

(B) saltiness of a pretzel

A. hearing

B. taste

C. smell

D. touch

E. sight

(Acceptable responses are given in parentheses.)

OBSERVING PLANET G

OBJECTIVES

Processes

1. Identify the appropriate sense needed to make an observation.

2. Distinguish between an observation and a non-observation.

REFERENCES

National Aeronautics and Space Administration. NASA Facts, Vol. IV, No. 4
Baltimore County Board of Education. Tape I, Unmanned Probe
Baltimore County Board of Education. Film Loop I, Zooming in On Planet G
Secondary School Science Project. Time-Space-Matter, Teacher Folio for Investigation 3. pp. 3-5

TEACHING SUGGESTIONS

Preparation

Part A

Read NASA Facts for background concerning space probes. This activity is not intended as a detailed study of space exploration, however.

Preview the film loop. It produces an effect of approaching the earth in a spaceship. Approximate showing time is two minutes. Read the script of the tape.

Part B

You will need the following materials for the demonstration:

beaker, 600 ml, 2
tapwater, 400 ml
vinegar, 400 ml, or a 5% solution of glacial acetic acid
  (To prepare this solution, add 20 ml acetic acid to 380 ml tapwater.)
ice cube, 1
halite, 1 piece approximately the same size as the ice cube

Procedure

Part A

The student activity sheet is a blank page. Students can list basic vocabulary used in this lesson, such as telemetry and probe, as well as their observations and judgments (inferences).

Begin by playing the tape, in which a flight director describes the descent toward Planet G. When the flight director says, "Activate camera," show the film loop, Zooming in on Planet G.

Now tell the students that there has been a great deal of controversy about the nature of Planet G. Ask them what they observed as they listened to the tape and viewed the loop. Make a complete list of the observations on the chalkboard. Rerun the loop, stopping it at various frames. Ask the students to verify, extend, or modify the list of observations. Then have the class group the items in the chalkboard list as things that can be observed and things which cannot be observed. For example, naming a color results from observation, but calling the white irregular features in the loop "clouds" results from inferences. Further, curvature of the edge of the picture can be observed, but the students cannot observe that the planet is a sphere--and, in fact, it may not be a sphere. The tape refers to "2,000 km." A kilometer is about 5.8 mile and, therefore, the distance is approximately 1250 miles.

Part B

In this demonstration, students observe a simple system that gives them a further opportunity to distinguish between observation and inference.

> On the demonstration table, place two liquid-filled beakers, one containing 400 ml of water and the other 400 ml of vinegar (or acetic acid solution). Put the halite in the beaker containing the water. To avoid splashing, tip the beaker and slide the halite into it. Put the ice cube into the vinegar in the same manner.

Have students list their observations. Refer to the Time-Space-Matter reference for a more detailed explanation of the halite and ice cube demonstration.

Script for Unmanned Probe

CAPE CONTROL: This is Cape Control. We are now thirty hours into the launch of Planet Probe G. Our telemetry station in Zabic reports all systems are AOK, with the exception of some minor problems in the navigation system. In a few moments we should have confirmation of Probe G approaching photographic range. At this time we will activate the television camera to take the first close-up photographs of the planet. If the Probe functions properly, we should be able to activate the camera at 1, 000 kilometers and continue to take photographs for about two minutes. We are now standing by for a report from Zabic on the altitude of the Probe and when the camera will be activated.

(Pause)

ZABIC: Cape Control. Cape Control, this is Zabic Telemetry Station. Do you read me?

CAPE CONTROL: This is Cape Control. Your reading is affirmative, Zabic. Over.

ZABIC: We will be able to give you a countdown to start the camera in a very few minutes.

CAPE CONTROL: Roger, Zabic. We affirm.

(Pause)

ZABIC: Probe G is now 2, 000 kilometers from Planet G. We now have T minus 20 seconds and counting.

CAPE CONTROL: Roger, Zabic.

ZABIC: The time is T minus 12, ... 11, ... 10, ... 9, ... 8, ... 7, ... 6, ... 5, ... 4, ... 3, ... 2, ... 1, . . Activate camera.

CAPE CONTROL: The camera has been activated, Zabic, and it looks good thus far. Over and out.

1A-3

A CLOSER VIEW OF PLANET G

OBJECTIVES

Processes

2. Distinguish between an observation and a non-observation.

1. Identify the appropriate sense needed to make an observation.

REFERENCES

Baltimore County Board of Education. *Slides of Planet G*

TEACHING SUGGESTIONS

Preparation

1. Use the following materials to set up a moth-ball demonstration:

    beaker, 1000 ml
    water, 800 ml
    acetic acid, glacial, 40 ml
    food coloring, 1-2 drops
    bicarbonate of soda, 1 tsp
    moth balls, 4

    Add the water and food coloring to the beaker. Dissolve the acid and bicarbonate of soda in the liquid.

2. Preview the 6 *Slides of Planet G.* They include:

    Slide #1. View of snow-capped mountain peaks; clouds are forming near the snow
    Slide #2. View of ice floes in water; sun low in the sky
    Slide #3. View of eroded rocks in desert region
    Slide #4. View of forest; moss-covered logs in foreground
    Slide #5. View of seashore; waves crashing on rocks
    Slide #6. View of flowers in sandy region; vegetation in background

Procedure

1. As motivation for the first process objective, have the set-up for the moth-ball demonstration on the front table. Drop the 4 moth-balls in the solution. They will immediately sink to the bottom and then will rise and fall in the liquid for 2 to 3 hours.

The reaction of the soda and acid forms carbon dioxide. These bubbles collect around the moth-balls, increasing their volume and decreasing their density. This gives them the ability to displace their own weight and rise in the solution. Upon reaching the surface, the carbon dioxide bubbles break, dispersing the CO_2 in the air. This decreases the volume and increases the density so that the moth-balls can no longer displace their own weight. Consequently they drop to the bottom of the beaker. If the action of the moth-balls slows down, add 1/4 tsp of bicarbonate of soda to the solution. Do not explain the reason for the reaction because the demonstration will be used again in a later lesson and explained to the student.

2. Show Slide #1. While the slide is on the screen have the students write their own observations in the chart in the manual. Show Slide #2 and continue this procedure for the remaining slides. Allow the students to complete Items 2 and 3 in the student manual.

3. Write the descriptive terms on the chalkboard, as given by the students, and ask the following question, "Are these really observations"? Accept all responses, but point out the difference between observations and non-observations.

4. Continue the group discussion by asking for responses to Interpretation Items 1 and 2. Interpretation Item 3 is an individual activity. Allow the students about 5 minutes to write their descriptions of Planet G. Then ask several students to read their descriptions orally.

Expected Results

1. A closer view gives detail; you can see more detail for different areas of Planet G than you saw in the film loop.

2. The viewing conditions were more favorable when the second set of pictures were taken; the photographic equipment was better for the second set of pictures; they were taken at closer range.

3. Students will undoubtedly give a variety of responses. Some of these may be strictly observations and others a mixture of observations and inferences. In any case, accept all descriptions of Planet G as given.

Assessment Task

An assessment task has been provided on the following page. It may be duplicated and administered as a test for the first process listed in this activity.

Acceptable responses are:

1. N
2. N
3. N
4. N
5. N
6. N
7. N
8. N
9. O
10. N

Assessment Task

A milkman deliverd two bottles of milk, which were left on the doorstep overnight. In the morning you see that the bottles are cracked and that the bottlecaps are on top of columns of solid milk.

Consider each statement below and indicate whether it is an observation (O) or a non-observation (N).

_____ 1. The same thing would have happened if water had been in the bottle.

_____ 2. Milk contains a lot of water.

_____ 3. The milk was changed from a liquid to a solid.

_____ 4. The caps were pushed up by the milk.

_____ 5. The bottles cracked when the milk expanded.

_____ 6. Milk expands when it freezes.

_____ 7. The temperature dropped below the freezing point during the night.

_____ 8. The milk expanded.

_____ 9. The milk was solid when you found the bottles.

_____ 10. It was winter.

SURFACE SAMPLES FROM PLANET G

OBJECTIVES

Processes

3. Name the qualitative characteristics of objects, using one or more of the senses.

4. Distinguish among objects on the basis of observable characteristics.

REFERENCES

1. National Aeronautics and Space Administration. NASA Facts, Vol. IV, No. 40. 1967.

2. Baltimore County Board of Education. Laboratory Safety Manual.

3. Baltimore County Board of Education. Slides from Planet G.

TEACHING SUGGESTIONS

Preparation

Prepare the surface samples by placing the following items in vials:

pebbles
sand
seawater (salt water)
fresh water
wood
air

These particular materials are included to represent a variety of surface materials that could have been collected from the sites shown in the slides in 1A-2. Small sticks, algae, leaves, etc., can be used either as additional or optional samples. Number and stopper the vials and place each set in a cigar or shoe box.

Cautions

This is a good opportunity to teach laboratory safety techniques early in the year. The materials in the vials are safe, but the students have no way of knowing this. In a real situation, precautions should always be taken; for example unknown liquids are never tasted and unknown gases are never smelled directly. Warn students not to contaminate the samples by exposure to air and other samples.

Procedure

1. Introduce the investigation by discussing any current space explorations.

2. Then have students read the introduction. Discuss any questions that arise. For example, students may question the fictitious probe. However, try to continue this story line because the activities have been developed to lead students toward the questioning attitude that is required of all science-based exploration.

3. Distribute the surface samples and permit the student groups to complete Item 1. Allow students to handle all materials in any way they choose. Some of them will undoubtedly want to taste and smell everything. If so, refer to the information listed under "Cautions." Items 2, 3, and 4 require students to classify or group materials. However, this is not the main purpose of this investigation.

4. Have each group lists the results of Item 4 on the chalkboard and then discuss the interpretation questions with the class.

5. Summarize the lesson by reshowing the Slides from Planet G. As the students look at each slide, have them name the characteristics of a sample that might have been collected from that site. For example, the sand could have been collected from the sites shown in Slides 3, 5, or 6.

Expected Results

1.

Sample #1	Pebbles: Students may mention state, color, and size; or they may attempt to name them.
Sample #2	Sand: Color, state, size, and texture; or the name
Sample #3	Seawater: Color, state, taste, etc.
Sample #4	Fresh Water: Color, state, taste, etc.
Sample #5	Wood: Shape, color, size, and state; or name
Sample #6	Air: Color, state of matter; or name

2. states of matter
color
source of material or geographic location
texture of samples
heft

3. physical properties or observational features

Responses to Interpretation Items

Accept all ideas, since the point of the investigation is that there can be diversity among groupings.

1A-5

USE OF INSTRUMENTS

OBJECTIVES

Processes

4. Distinguish among objects on the basis of observable characteristics.

5. Demonstrate the ability to use instruments in making observations.

Concept

What an observer sees depends upon his position and the limits of the instruments he uses.

REFERENCE

Beauchamp et al. Everyday Problems in Science (1963 ed.) pp. 17-22.

TEACHING SUGGESTIONS

Preparation

Obtain a hand specimen of granite and of the large synthetic granitic rock.

Procedure

1. Have both specimens on the demonstration table. (If the synthetic rock is not available, use the hand specimen alone to demonstrate the concept.) Hold up the granite specimen and ask a student in the rear of the room to describe it. Difficulties will arise due to the distance between the sample and the observer. Then ask a student nearer the sample to describe it. Hold up the large synthetic rock and ask another student from the rear of the room to describe it. Then ask a student nearer the specimen to describe it. After descriptions of both specimens have been obtained, hand the small specimen to one student and the synthetic rock to another. After the students realize that the large specimen is synthetic, bring out the idea that what the observer sees depends upon the viewer's position.

2. If the Beauchamp reference is available, have the students read

about a variety of instruments used by scientists. Ask the students to answer the question, "In what ways do different instruments extend our senses?"

3. Before distributing the materials for the investigative part of this activity, demonstrate the correct use of a hand lens. It is most important that the lens first be placed close to the eye and then the sample brought toward the lens until clear focus is obtained. Explain what is meant by "in focus." For example, you might say that you can see the specimen most clearly at this point.

4. Distribute the materials. Have each student practice using the lens by trying to bring his thumb into focus.

5. Have each student open his manual to Page 9 and cut the measuring strip from the bottom of the sheet. All units are in centimeters, but students are not required to learn the terms of the metric system at this time. Explain that the letter "X" following a number on any magnifying instrument means that the specimen is being viewed at that number of times its actual size. For example, 10X means that the specimen appears to be 10 times its actual size. Permit the student groups to complete all investigation items.

With the recent advances in science and technology, the discussion of instruments provides a good opportunity to use current science. As an optional activity, assign readings on the development and use of electron microscopes, lasers, masers, and other instruments that enhance the senses.

Anderson. Through the Microscope. pp. 11-13
Beise. Guide to the Microscope. pp. 16-18
Cosgrove. Strange Worlds Under a Microscope. pp. 1-13
Klein. Masers and Lasers.

Expected Results

2.

B	C	D
2 times	3 times	4 times

4. The answer to this item is determined by the magnification of the lens used by the students.

Responses to Interpretation Questions

1. See Item 4 above.
2. binoculars
   microscopes
   stereomicroscopes
   telescopes

Discussion

Raise the question, "In what ways do different instruments extend our senses?" Some examples:

telescope - makes distant objects appear nearer
microscope - makes small objects appear larger
analytical balance - measures very small masses
spectroscope - analyzes composition of materials, their temperature, and movements
thermometer - measures temperature

INVESTIGATING ROCKS

OBJECTIVES

Processes

3. Name the qualitative characteristics of objects, using one or more of the senses.

4. Distinguish among objects on the basis of observable characteristics.

5. Demonstrate the ability to use instruments in making observations.

Concept

The many different kinds of rocks are distinguishable by such characteristics as color, luster, hardness, and texture.

REFERENCES

American Geological Institute. Geology and Earth Sciences Sourcebook.

Earth Sciences Curriculum Project. Investigating the Earth. Teachers' Guide - Part I. pp. 70-72

Zim. Rocks and Minerals

TEACHING SUGGESTIONS

Preparation

1. For each student group, obtain one set of the following rocks:

granite, pink	-	coarse-grained; containing pink orthoclase, glassy quartz, black biotite, and possibly black hornblende
marble, white	-	fine-grained, recrystallized limestone
gneiss	-	coarse-grained; containing quartz, feldspar, and biotite

basalt - dark-colored, fine-grained, igneous rock; crystals of feldspar, pyroxene or olivene set in a fine-grained groundmass

schist, mica - highly metamorphosed shale composed of many flakes of banded mica and quartz; may include garnets

sandstone, white - fine grains of quartz cemented by silica

2. If you plan to use fragments as well as whole rock samples, prepare slides for use with the stereomicroscopes. Smear on a microscope slide a small amount of Elmer's glue, airplane cement, or any adhesive that is clear. This will hold fragments on the slide.

3. It is convenient to number now all the rocks that will be used in Grade 7. Use sticker labels or number directly with airplane paint or a magic marker. Assign the following numbers to the rocks:

    #50 - basalt
    #51 - gneiss
    #52 - granite, pink
    #53 - marble, white
    #54 - quartzite, white (This rock will be used later.)
    #55 - sandstone, white
    #56 - schist, mica
    #57 - pumice (This rock will be used later.)

Procedure

1. Review the correct use of a hand lens. If a stereoscope is to be used, demonstrate it also.

2. Recall to the students the different kinds of surface samples observed in IA-4. Present the materials in this order:

    1. vial containing air
    2. vial containing a liquid
    3. vial containing pebbles

    Ask this question, "Of the three samples, which would be the easiest for you to analyze or separate: i.e., to take apart to see what it is made of"? (The usual answer will be the pebbles.)

3. Distribute the rocks, hand lenses, and bank pins. Tell the students to examine each rock carefully with a hand lens and to use the bank pin to scratch or break off small fragments of the rock. As the students begin to work, point out that they are extending the techniques of observation and description.

4. When you feel that most of the students have completed their lists, compile a master list of the students' terms on the chalkboard.

5. Tell the students to complete the interpretation item from the master list on the chalkboard.

Expected Results

The following are examples of terms students use to describe rocks:

Rock #50 (basalt)	Rock #51 (gneiss)	Rock #52 (granite)	Rock #53 (marble)	Rock #55 (sandstone)	Rock #56 (schist)
black or dull smooth surface heavy very small-grained speckled sharp edges	layered or banded granular large or medium grained sparkling speckled sharp edges hard rough flaky pink black white rosy different colors	grainy or granular sharp edges hard rough pink black speckled white sparkling	white light-colored shiny sparkling small-grained gray-streaked	grainy or granular sandy layered small-grained light-colored rounded edges flat	sparkling rough rough edges jagged banded or layered breaks easily grainy white or gray black brown various sizes dark red large grains

Responses to Interpretation Questions

During the discussion of the interpretation items, explain that terms such as "rounded," "angular," "flat," and "dull" are not very useful in differentiating one rock from another. Terms applying to only part of a rock, such as "sparkling" or "white pieces," are also not very helpful. Certain terms and phrases, such as "layered" or "banded," "grainy," and "larger crystals in a fine background," leave little doubt about which rock is being described. These are textural terms and describe the way in which the individual parts of the rocks are put together. Texture is the size, shape, and arrangement of mineral grains and other components in a rock.

IA-7

A CLOSER LOOK AT A ROCK

OBJECTIVES

Processes

3. Name the qualitative characteristics of objects, using one or more of the senses.

4. Distinguish among objects on the basis of observable characteristics.

5. Demonstrate the ability to use instruments in making observations.

Concept

A mineral is a naturally-occurring, crystalline, inorganic substance with physical and chemical characteristics that vary within limits.

REFERENCES

American Geological Institute. Geology and Earth Sciences Sourcebook.

Earth Sciences Curriculum Project. Investigating the Earth, Teachers Manual - Part I. pp. 72-73

Ramsey. Modern Earth Science (1969 ed.). p. 172

TEACHING SUGGESTIONS

Preparation

1. Prepare crushed pink granite. Wrap the rock in several thicknesses of paper towel and crush with a hammer. This is

---

Students are not expected to define a mineral in these terms. A seventh grade student usually defines a mineral as a one-of-a-kind material that is found by itself. This is acceptable.

best done on a metal or concrete surface. If a student assists in this preparation, make sure that he wears safety goggles. For each student group put about 5 cc of the sample in a stoppered vial.

2. Study the Mineral Identification Key, Pages 95-96 in the student manual. The numbers on the student key are for reference only. They are not the code numbers. The following list gives the code numbers to be placed on the mineral specimens. They correspond to the numbers used in the data charts in the student manual.

No.	Name	No.	Name
1.	apatite	15.	hematite
2.	asbestos	16.	hornblende specular
3.	biotite	17.	magnetite
4.	calcite crystal	18.	muscovite
5.	calcite, rhombic	19.	obsidian
6.	corundum	20.	pyrite
7.	feldspar	21.	quartz crystal
8.	fluorite	22.	quartz, milky
9.	galena	23.	talc
10.	garnet	24.	topaz
11.	graphite	25.	tourmaline
12.	gypsum	26.	sulfur
13.	halite	27.	wernerite
14.	hematite	28.	willemite

It is recommended that all the minerals be labeled with the assigned code now, since all will be used in succeeding investigations. Use magic marker or airplane paint.

3. For the summary (Procedure Item 3, below) have at hand the following minerals: #22, quartz; #7, feldspar; #16, hornblende; and #3, biotite mica.

4. Prepare a quantity of synstone, which may be used in an optional activity or for an assessment task, as follows:

   Add a variety of easily identified materials to dry plaster of Paris; for example, copper shot, coarse iron filings, rock salt, iron turnings, sulfur, coarse sawdust, and coarse cork dust. If other materials are used, make sure that they are safe by checking the Baltimore County Chemical Safety Manual. Add water and stir to make a paste. Pour into paper cups and allow to harden overnight. Peel off the cups the next day.

Procedure

1. Distribute the rock samples (granite) and have the students fill in Procedure Item 1. Students should see that the sample is made up of parts.

2. Distribute the rest of the materials. Let the students use stereomicroscopes if they are available. Tell them that they will now take a closer look at one of the rocks studied in the preceding lesson and describe its components in their own words. Ask, "Is it made up of only one kind of material or of different kinds of material"? If students say it consists of different kinds of material, ask, "How do you know this"? Tell students to keep these questions in mind as they examine the crushed material. Have them use the bank pins to divide the rock pieces into piles of similar-looking materials. They should ignore any mixed grains, or if they wish, put them into a separate pile. If anyone is having difficulty, ask questions such as, "Are all of the materials the same color"? or "Do any of the materials appear to have a consistent shape, or broken surface"? The students have been asked to list the terms that describe the way the materials in the rock look. What they are actually doing is making observations of mineral properties.

3. Summarize the work by showing Figure 8-18A, Page 172 in the Ramsey reference on an opaque projector. (Check page number in older editions.) If the reference is available in class quantities, let the students look at the figure directly. The picture shows that granite is compsed of four mineral groups: quartz, feldspar, mica, and hornblende. Have samples of these minerals available for student examination after they have seen the picture.

4. If you plan to use synstone as an optional activity, proceed as follows: Distribute a sample of the synstone to each student. Have the student take the material home, examine it thoroughly, and write a complete description of the unknown material. The student may use any method or tools in examining the unknown material.

5. Tell each student to begin collecting interesting rocks from around his home or community. A minimum of 6 different rocks will be needed for 1A-10 and 1A-29, but a student may make a larger collection if he is interested.

Expected Results

1. Responses will vary.

2. There should be at least three piles: quartz, feldspar, and mica. In addition, there may be minor amounts of other minerals such as hornblende.

3.

Substance #1 (quartz)	Substance #2 (biotite)	Substance #3 (feldspar)	Substance #4 (hornblende)	Substance #5
transparent shiny glassy breaks irregularly	black shiny flaky or platy	rose pink milky colorless chunky breaks angularly	dull greenish-black elongated	

Responses to Interpretation Questions

1. A greater variety of terms is used to describe the rocks in the preceding activity, "Investigation Rocks." Fewer terms are needed to describe minerals.

2. Minerals are easier to describe than rocks because rocks are mixtures of minerals.

3. A rock is made up of minerals that vary in size, shape, and arrangement. For the definition of a mineral, see the concept listed under "Objectives."

DETERMINING HARDNESS OF MINERALS

OBJECTIVES

Processes

5. Demonstrate the ability to use instruments in making observations.

6. Demonstrate the ability to select the proper instrument to extend observations of qualitative characteristics.

Concept

Minerals can be identified in part by hardness.

REFERENCES

American Geological Institute. Geology and Earth Science Sourcebook. pp. 10-11

Thurber and Kilburn. Exploring Earth Science. p. 213

TEACHING SUGGESTIONS

Preparation

1. Make up the kits needed for this activity. You will need enough Hardness Kits #1 to supply one to each student group. Include the following in Kit #1:

penny, or copper electrode
nail
glass slide
steel file

minerals:
- #5, calcite
- #6, corundum
- #8, fluorite
- #22, milky quartz
- #23, talc

2. Because Hardness Kit #2 is to be used as an individual assessment, it would be ideal to have one kit per student. Since this is economically impossible, make up as many as you have materials for. Include:

   penny, or copper electrode
   nail
   glass slide
   steel file

   3 numbered specimens:
   #8, fluorite or #1, apatite
   #12, gypsum or #23, talc
   #24, topaz or #21, quartz crystal

   Limit your selection to these minerals, because the others in the Mineral Identification Key will be used in later activities.

3. The minerals used in this investigation have the following hardness according to Moh's Scale:

talc	1	feldspar	6
gypsum	2	quartz	7
calcite	3	topaz	8
fluorite	4	corundum	9
apatite	5		

4. The tools used have these standards of hardness:

fingernail	2.5
penny	3.0
nail	5.0
glass	5.5
steel file	6.5

Procedure

1. As an introduction, refer to the previous investigation, in which the students discovered that a rock is made of several different minerals. Ask, "What is a mineral"? Hold up four minerals used in the preceding lesson: quartz, feldspar, hornblende, and biotite mica. Ask, "What makes them different"? The students usually say, "Color or shape." At this point, tell the students they are going to learn that hardness is one method of identifying minerals.

2. Distribute the Thurber and Kilburn reference and ask the students to read Page 213 and complete Part A in their manuals. Check the answers and discuss any discrepancies.

3. Distribute Hardness Kit #1 and explain the use of the hardness test materials. Tell students that hardness is the resistance that a smooth surface of a mineral offers to scratching: its "scratchability." Each mineral in the hardness scale can be scratched by any mineral with a larger hardness number, and will scratch any mineral with a lower hardness number. Point out that the scale is relative. Students should not get the idea that gypsum is twice as hard as talc, or diamond ten times as hard as calcite. These indices are not ratios. The students may use the Thurber and Kilburn and Part A of the procedure to arrange the minerals in order of hardness.

Expected Results

Part A

1. c
2. a
3. a
4. d

5. (a) 2.5
   (b) 3
   (c) 6.5
   (d) 5.5
   (e) 7
   (f) 8
   (g) 10

Part B

Mineral	Scratched by				
	Fingernail	Copper Penny	Nail	Glass	Steel File
5 (calcite)		X	X	X	X
6 (corundum)					
8 (fluorite)			X	X	X
22 (quartz)					
23 (talc)	X	X	X	X	X

2.

Mineral	Hardness Number
5	3
6	9
8	4
22	7
23	1

Assessment Task

As each student finishes work, hand him Hardness Kit #2. Tell him to arrange the minerals in order of hardness, from the lesser to the greater, assigning the letter "A" to the softest, "B" to the harder, and "C" to the hardest. Do not require students to assign the hardness numbers to their specimens.

If desired, have students use the Hardness Chart in the Thurber and Kilburn reference to suggest possible identities for the minerals in Kit #2.

DETERMINING APPEARANCE OF MINERALS

OBJECTIVES

Processes

5. Demonstrate the ability to use instruments in making observations.

6. Demonstrate the ability to select the proper instrument to extend observations of qualitative characteristics.

Concept

Properties such as color, luster, streak, fracture, and cleavage are useful for identifying minerals.

REFERENCES

American Geology Institute. Geology and Earth Science Sourcebook.

Thurber and Kilburn. Exploring Earth Science. pp. 213-214

Zim. Rocks and Minerals. pp. 20-21

TEACHING SUGGESTIONS

Preparation

Remove the following materials from Hardness Kit #1:

penny, or copper electrode
nail
glass slide
steel file

Add the following minerals:

#2, asbestos
#3, biotite
#4, calcite
#7, feldspar
#9, galena
#10, garnet
#13, halite
#14, hematite
#17, magnetite
#18, muscovite
#19, obsidian
#21, quartz crystal

Also add: streak plate

Procedure

1. Distribute the Zim and Thurber and Kilburn references and have the students read and fill in the items under Procedure in their manuals. Note that the terms listed under luster, fracture, and cleavage have been simplified. Luster is usually divided into metallic and non-metallic. The seven types of fracture have been simplified to two types: conchoidal and uneven. Cleavage is the way some minerals split along planes, leaving flat surfaces; for example, the cleavage formed by mica is basal or one-sided.

2. Distribute the revised kits, each containing 17 minerals and a streak plate. Have the student groups complete the interpretation item. This will probably take more than one class period. It is not necessary for the students to name the minerals or the crystal forms; this will be done later.

Expected Results

1.

a. 1) rough
   2) luster

b.

metallic	d
glassy	c
pearly	a
dull	b

2.

conchoidal	B
uneven	C

3.

one side	C
two sides	A
three sides	B

Responses to Interpretation Questions

Refer to the Mineral Identification Chart on Pages 95-96 of the student manual and to the key in the Teaching Suggestions of 1A-7 for correct responses.

Assessment Task

Distribute the following:

#11, graphite
#12, gypsum
#20, pyrite
#28, willemite
streak plate

Duplicate the chart found on the next page and distribute to the students.

Assessment Task

Complete the chart by describing the properties of each mineral. Match the number on the specimen with the number on the chart.

No.	Color	Luster	Streak	Cleavage	Fracture
11					
12					
20					
28					

1A-10

COLLECTING ROCKS

OBJECTIVES

Process

6. Demonstrate the ability to select the proper instrument to extend observations of qualitative characteristics.

REFERENCES

Baltimore County Board of Education. Slides of Planet G; Film Loop, Zooming in on Planet G; Tape, Unmanned Probe.

Zim. Rocks and Minerals. pp. 4-13

TEACHING SUGGESTIONS

Preparation

1. Review the audiovisual aids listed above. These have been shown previously.

2. Students were told to begin collecting samples of rocks in 1A-7. However, it is wise to have on hand a supply of rock samples to make up for deficiencies in the ability or motivation of individual students.

Procedure

1. This is a summary lesson covering the first six objectives in the hierarchy.

2. Before using the audiovisual material, direct the students' attention to the current series of manned space flights. Tell the students to review the loop and slides as though they were astronauts approaching an unknown planet. Ask the following question, "What possible dangers are the astronauts facing"? List answers on the chalkboard. Then ask, "What preparations must astronauts make to avoid such hazards"?

3. Show the loop and play the tape. Then show the slides.

4. Have the students complete Items 1 and 2 in Part A.

5. Distribute the Zim reference and ask students to complete Items 3 and 4 in Part A.

6. Discuss students' answers to Part A, but reserve time for #7 below.

7. Tell students to read Item 1 of Part B. Explain the rock crushing process. (See the Teacher's Guide for 1A-7.)

8. Part B will probably require more than one class period and can be used as an assessment task. Since most students will not be familiar with the rocks in their collections, the samples will be unknown and might as well be from an unknown planet. Carry out this theme if you feel it has interest value.

9. Before setting the students to work, review the procedure for separating a rock into its constituent minerals. Refer to Investigation 1A-7 and the Mineral Characteristics Chart on Pages 95-96.

10. Ask students to complete the forms (one for each rock) in the latter pages of this investigation. You may need to review the five properties of minerals listed on the forms. The forms have space for five minerals per rock; not all rocks have this many identifiable minerals so all spaces are not needed.

11. Do not require the students to identify their rock samples. They may do so if they wish, but you should not put yourself in the position of a referee on the technicalities of petrology and mineralology.

12. Concurrently with the laboratory work, students may be asked to do some outside reading related to space exploration. Suggested materials are:

    Harris. Living in Space

    National Academy of Sciences. National Goals in Space, 1971-1985. IG Bulletin #90. December 1964.

    Life Magazine. Destination: The Moon. Educational Reprint #25.

    Perkinson, William J. Apollo: The Road to the Moon and to the Planets. Baltimore Evening Sun Reprint. 1969.

Expected Results

Part A

1. Binoculars, telescopes, radar, geiger counters, and even answers such as shovels are acceptable.

2. From a study of the rocks of the moon, scientists can better understand the formation of the earth and our solar system.

3. a. Along railroads, in riverbeds, on seashores, at road construction sites, etc.

   b. 1. hammer
      2. chisel
      3. magnifying glass
      4. paper for wrapping specimens
      5. notebook and pencil
      6. field bag
      7. heavy gloves
      8. compass

4. See Page 11 in the Zim reference.

Part B

For suitable responses refer to the Mineral Identification Chart. Remember that identification of rocks or their constituent minerals is optional. The objective of this investigation is to have a student demonstrate an ability to select the proper instrument to extend their observation.

Assessment Task

Part B has been designed to assess the first 6 objectives in the hierarchy. Students should work individually.

DISCOVERING ANOTHER CHARACTERISTIC

OBJECTIVES

Process

7. Distinguish between qualitative and quantitative characteristics of objects.

Concepts

1. Many characteristics are needed in order to identify minerals.

2. Some mineral characteristics can be observed with the unaided senses but others must be measured.

REFERENCES

Namowitz and Stone. Earth Science, The World We Live In (1969 ed.). pp. 24-25
Zim. Rocks and Minerals. p. 19
Herron and Palmer. Matter, Life, and Energy. pp. 98-100
Blanc, et al. Modern Science 3. pp. 138-144

TEACHING SUGGESTIONS

Procedure

This activity serves as a transition from qualitative characteristics to characteristics that involve quantitative observations, such as specific gravity and density. Have the students do the investigation by referring to the chart and then answering the questions.

Responses to Interpretation Questions

1. A. color, hardness, specific gravity, cleavage, and fracture
   B. color, streak, cleavage, fracture, and luster
   C. hardness, specific gravity, cleavage, and luster
   D. specific gravity

2. Most students should indicate that they can perform all the tests except specific gravity.

3. Specific gravity

Discussion

Use Interpretation Item 3 to show students that they are not able to carry out the test necessary to distinguish between Mineral Samples A and C because they do not know how to find specific gravity. Some students may have heard the term "specific gravity" or have an idea of its definition. Tell the class to use a reference to find or verify the meaning of the term. Definitions are likely to include many unfamiliar terms, such as density, volume, and mass. List these on the chalkboard. Develop the idea that to measure specific gravity, one must be able to measure volume and mass as well as understand the meaning of such units as centimeters, cubic centimeters, grams, etc.

A PRINCIPLE OF MEASUREMENT

OBJECTIVES

Process

8. Demonstrate a procedure for using the metric system to determine length.

Concept

Standard units are needed when comparing measurements.

TEACHING SUGGESTIONS

Procedure

1. As an introduction, ask questions such as:

   a. How much do you weigh?
   b. What is your height?
   c. What is the distance from home to school?
   d. How long does it take you to get to school?
   e. What is the area of the top of your desk?

   Accept all responses, but ask the students to tell how they arrived at their answers. Students will probably mention bathroom scales, rulers, automobile odometers (they may call them speedometers), and watches. Guide students to recognize that some kind of measuring instrument is necessary to answer any question like those above. Stress the difference in accuracy between their answers to Questions a through d and their answers to e. Ask the students what kind of measurement is needed to answer Question e.

2. Have students clear their desks of everything but a pencil or pen, a sheet of paper, and the student manual. Tell them that these are the only materials that will be provided; and they will be expected to use their imagination to develop a way of making measurements. Under no circumstances should students be allowed to use standard measuring devices such as rulers, yardsticks, or meter sticks. They should be able to think of such units as width of hand, length of paper, and thumb width.

Expected Results

Answers will vary depending upon the arbitrary units chosen.

Responses to Interpretation Questions

1. Some students may report approximately the same measurement of objects if they happened to use the same standard units of length, such as a sheet of paper. However, other students will report different measurements because they will have used different standards, such as lengths of pencils or pens.

2. The desk tops are probably approximately the same length. Most of the class measurements will not indicate this, however, because of the variety of units of length used to measure them.

3. It is necessary to use the same unit of measurement when comparing measurements. If different units of measurement are compared, there is no possibility for agreement.

4. They should have a definable standard unit of length.

Class Discussion

Point out that any unit that is definable can be used for measurement. The important thing is that everyone who uses the measurements must agree upon the unit; otherwise they cannot communicate with each other.

MEASURING LENGTH

OBJECTIVES

Process

8. Demonstrate a procedure for using the metric system to determine length.

Concepts

1. The meter is the standard unit of length in the metric system.
2. The units of the metric system are related by powers of 10.

REFERENCES

Physical Science Study Committee. Physics (1965 ed.). pp. 22-31

Swartz. Measure and Find Out, Book Two.

TEACHING SUGGESTIONS

Procedure

1. Distribute the white, orange, and blue measurement standards (white = 1 cm, orange = 10 cm, blue = 100 cm). The 100 cm units will probably have to be color-coded blue by you. Do not name the units at this time. Tell the students to use as many of the units as necessary to get accurate measurements.

2. Be sure to discuss the interpretations for Part A before students begin Part B. In this discussion, make a combined list of student measurements of the paper and of the chalkboard so the class can evaluate their consistency. Once the metric terminology has been developed, insist that the students use it exclusively. Do not require students to make conversions between the English and metric systems.

3. For Part B, provide commercial meter sticks as well as the colored units from Part A. Students should realize that one white unit is a centimeter, one orange unit is a decimeter, and one blue unit is a meter.

Assessment Task

Distribute the following materials to each pair of students:

- ring stand
- string, exceeding a meter but less than two meters in length
- paper with five different line segment lengths lettered A through E
- beaker, 400 ml
- meter stick
- chart as shown below

Have students work individually without talking during this assessment task, even though materials are shared. Tell the students to measure the items indicated in the chart and fill in each space in the chart marked with an X.

ITEMS	MEASUREMENTS			
	Millimeters	Centimeters	Decimeters	Meters
1. Length of ring stand base	X		X	X
2. Width of ring stand base		X	X	X
3. Length of ring stand rod	X	X		X
4. Length of string	X	X	X	
5. Distance around beaker	X		X	X
6. Line of Segment A			X	X
7. Line of Segment B			X	X
8. Line of Segment C			X	X
9. Line of Segment D			X	X
10. Line of Segment E			X	X

Acceptable responses: You must yourself make the measurements called for and decide upon an acceptable student deviation.

SIZES OF SURFACES

OBJECTIVES

Process

9. Demonstrate a procedure for determining area.

Concepts

1. The total area of a surface is equal to the number of standard units of area needed to cover the surface.

2. The area of square-cornered surfaces may be found by:
    a. counting the number of area units required to cover the surface; or by
    b. using appropriate formulas.

TEACHING SUGGESTIONS

Preparation

Students first use an arbitrary unit of area, the white unit. You need about twenty of these per group of two to four students. Make the white units from tagboard or similar material, to measure 1.5 centimeters. Package them in envelopes.

Procedure

1. Distribute an envelope containing the white area units to each group.

2. Tell students that they will have to estimate parts of area units if they cannot cover the space evenly. Surfaces A and B have been drawn so that an even number of white units fit on them. Surface C, however, is four units long and one and one-half units wide. If students have difficulty with Surface C help them to use parts of units to estimate the number of units needed to cover the entire surface.

3. After a discussion of this investigation you may wish to have students become familiar with area measured in square meters or square decimeters. To do this have students compute the area of the chalkboard surface, desk surface, or faces of paper boxes.

Expected Results

1. 4 area units

2. Length = 2 units; width = 2 units.

3. 2 units x 2 units = 4 area units.

4. Surface B: 8 area units; 4 units x 2 units = 8 area units.

   Surface C: about 6 area units; 4 units x 1 1/2 units = 6 area units. Students must estimate parts of area units and there may be some variation in answers.

5. They are equal.

6. 2 1/2 units x 6 units = 15 area units. This should agree with the "covering" check.

7. Surface E = 8 area units.
   Surface F = 4 area units.

8. Surface G = 10 area units.

9. square centimeter

10. Surface E = 18 cm^2.
    Surface F = 9 cm^2.

11. Surface G = 22.5 cm^2.

12. Surface H = 28 cm^2.

Responses to Interpretation Questions

1. The area was found by fitting square units on the surface and by multiplying length times width.

2. A square centimeter is in the shape of a square and measures one centimeter by one centimeter.

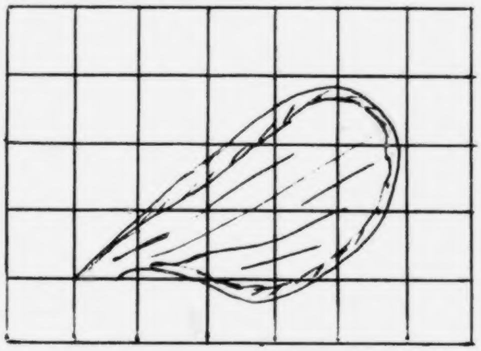
Acceptable Responses to Assessment Task

1. Any answer between 7 mm^2 and 9 mm^2 is an acceptable estimate.

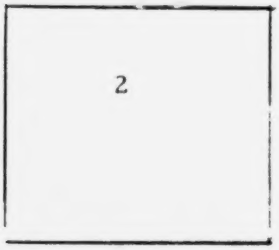
2. Figure 1. Students should use a centimeter scale to find the dimensions and then apply the formula A = LW.

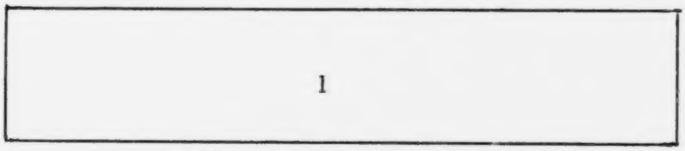
Assessment Task

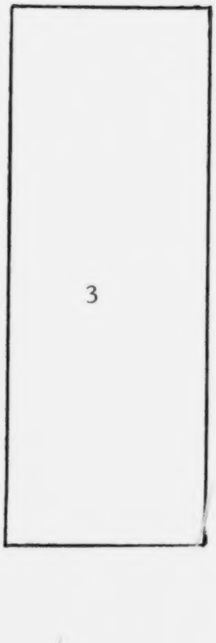
1. An insect wing is placed under a glass plate that is sectioned in square millimeters (mm^2). Under a magnifying lens it appears as illustrated at the right. Estimate the area of the wing in mm^2.

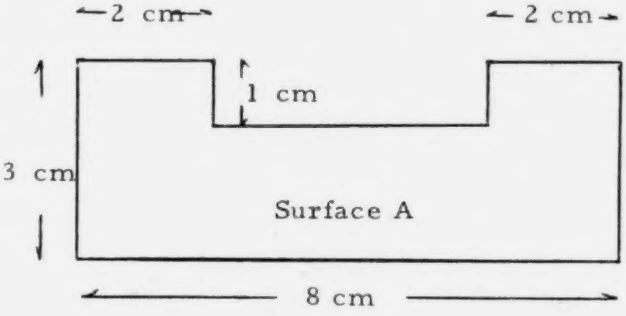


2. Which of the figures below has the same area as Surface A?








2 cm
2 cm
1 cm
3 cm
Surface A
8 cm

MEASURING THE SPACE THAT MATTER OCCUPIES

OBJECTIVES

Process

10. Demonstrate a procedure for measuring volume.

Concepts

1. A volume measurement gives the quantity of space occupied by matter.

2. The volume of many regularly shaped objects can be computed by multiplying area of base by height.

REFERENCES

Brooks, et al. Modern Physical Science.

Swartz. Measure and Find Out, Book Two.

TEACHING SUGGESTIONS

Preparation

Part A of the investigation requires 30 cubes (each one equals one cm^3) per group. A class divided into 20 groups needs 600 cubes. In Part B the rectangular solids can be cigar boxes, shoe boxes, chalk boxes, etc. Begin collecting the various rectangular solids a few weeks prior to the investigation. You need six different rectangular solids per group. Number them for identification.

Procedure

1. Hold up a large rectangular solid and pose the question, "How can you determine the amount of space occupied by this solid"? Students may suggest using small cubes that will fit into the solid. If a hint is needed, have the students recall the covering technique used in 1A-14.

2. Distribute materials for Part A. Circulate to make certain students are forming rectangular solids. Be sure students realize that the total number of cubes used in constructing their rectangular solids is the same as the product of the number of cubes along Edge A, Edge B, and Edge C. Point out that volume is measured by selecting a standard unit and then counting the number of standard units needed to fill a certain space.

3. When students have completed the discussion of the interpretation items of Part A, distribute materials for Part B. Allow students adequate time to perform the calculations. Tell the students that the volume of many geometric solids can be calculated by using appropriate mathematical formulas.

4. For a follow-up activity, have students find the meaning of cubic centimeter, liter, milliliter, and graduate in a reference. Discuss the relationship of these terms. Two useful references are Pages 23-24 in Measure and Find Out, Book Two, and Pages 8-9 in Modern Physical Science.

Expected Results

The investigation should lead students to the understanding that volume of a rectangular solid may be obtained mathematically either by taking the product of three linear dimensions (length, width, and height) or by multiplying the area of the base by the height.

Responses to Interpretation Questions

Part A

1. They are the same.

2. Multiply length by width by height.

Part B

1. The values should be the same when compared. If they are not the same, an error in measurement was made. It should be pointed out than an error of only one centimeter in one dimension can result in a large error in the product. For example: If a rectangular solid measures 5 cm x 6 cm x 7 cm, the volume is 210 cm^3. An error of one centimeter in one dimension would result in a calculated volume of 168 cm^3.

2. a. The answer is dependent upon the sample selected by the teacher.

   b. The volumes should be the same. There may be small differences due to measurement errors.

   c. The volumes should agree, or nearly so.

Acceptable Responses for Assessment Task

1. a. 45 blocks

   b. 45 cubic centimeters

2. Yes

Assessment Task

Directions: Answer the questions below.

1.

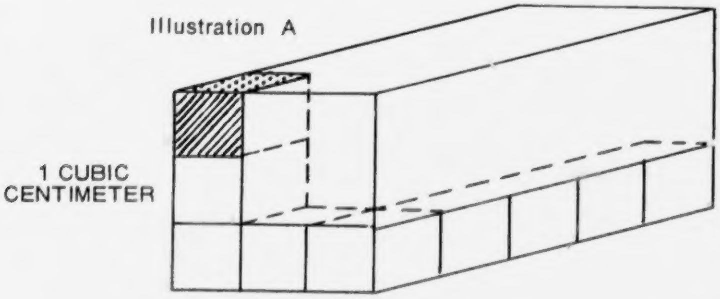


Illustration A
1 CUBIC CENTIMETER

a. How many one centimeter cubes can be placed into the rectangular solid in Illustration A?

b. What is the volume in cubic centimeters of the rectangle solid?

2.

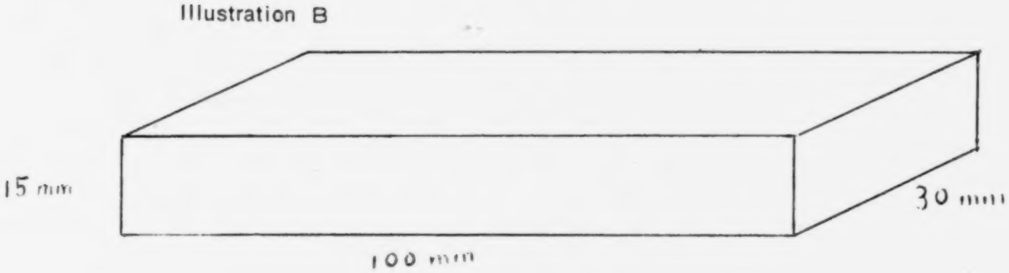


Illustration B
15 mm
30 mm
100 mm

Does the rectangular solid in Illustration B have the same volume as the rectangular solid in Illustration A? If not, how much larger or smaller is it?

A VOLUME-MEASURING DEVICE

OBJECTIVES

Process

10. Demonstrate a procedure for measuring volume.

Concepts

1. The volume of an irregularly-shaped object can be determined indirectly by the displacement of water.
2. A volume measurement gives the quantity of space occupied by matter.

REFERENCES

Swartz. Measure and Find Out, Book Two.

TEACHING SUGGESTIONS

Procedure

1. Before students start the investigation, carry out the following teacher demonstration:

> Obtain three rock samples, each with a large enough volume to displace a noticeable amount of water in a beaker and each noticeably different in volume from the others. Show the students the three rock samples and ask which is the smallest. Place the smallest sample in a beaker of colored water that has been marked to show the starting water level. When the sample is submerged, mark the new water level. Remove the sample, add any water necessary to bring the level up to the starting level. Ask which is the next larger sample. Submerge it in the water, and mark the level as before. Repeat the procedure for the third sample. Ask the students how the distance the water rose compares to the volume of the sample.

The students should see that the water rose in proportion to the volume of the rock. Then ask the students what caused the water to rise. Any responses indicating that the rock pushed the water aside is acceptable, but the term "displace water" should be introduced during this discussion. At the end of the discussion, the students should be able to state a rule that the rocks displaced water according to their volume.

2. After the students understanding the preceding concept, begin the investigation. Show the class an irregularly-shaped rock and pose the problem, "How could you determine the amount of space the rock occupies"? After getting suggestions for various approaches, pass out the materials for Part A and have students work in pairs.

3. In Part A of the investigation, students use clear plastic tubes with transparent tape attached to the sides. Each marble used in this investigation should have a volume of about two cubic centimeters. Tell students to be careful to avoid splashing the water when they put the marbles into the tube. One way is to tilt the tube and allow a marble to roll gently into the water. In Item 5 of the Procedure, watch that students keep previously-added marbles in the water when each new one is added.

4. For Part C, have the students remove the transparent tape from the plastic tubes. Supply the graduated labels separate from the tubes. The intervals on the label indicate 0.5 cc; however, allow the students to discover this for themselves. Advise the students not to number every calibration, but rather every other one. Since these labels can be reused from year to year, have all writing on the label done in pencil.

5. In Part C, students should see the relationship of cubic centimeters to milliliters and gain some facility in using the graduated cylinder. Use the aluminum cube and aluminum slab from the density kit or any two rectangular solids that have different volumes and that fit into the graduate. However, if substitute solids are used, you will have to measure and record their volumes in advance. The volume of the aluminum cube should be about 2 cm^3 and that of the aluminum slab should be about 11 cm^3.

6. As a follow-up to working with the graduated cylinder, you might display some examples of commercially-graduated devices such as measuring cups, graduated beakers, graduated flasks, and the various sizes of graduated cylinders. Have the students indicate the standard unit used for the graduation of each of the

devices that you display. Students may be given additional practice in measuring volume by doing the activities on Pages 25 and 26 in Measure and Find Out, Book Two.

Responses to Interpretation Questions

Part A

1. Each marble raises the water level the same distance.
2. They are approximately the same.
3. The water level would rise as much as it did for each preceding marble.
4. Yes. You could use the marble as the standard unit of volume and graduate the tube accordingly.
5. If the tube has a uniform diameter, you can measure the distance between two marks on the transparent tape and add marks at the same interval.

Part B

1. Each division marks 0.5 cm^3.
2. It is not important so long as you use the tube only to measure volume of solids by displacement. But if you want to measure the volume of a liquid, it is necessary to begin measuring from the bottom of the tube.
3. Yes. It would be possible if you matched the bottom line with the bottom of the inside of the tube.

Part C

1. They are about the same. The computed volume in cc should be approximately the same numerically as the volume in ml measured by the displaced water.
2. It should rise 35 ml.

Acceptable Responses to Assessment Task

1. c or e
2. e or c
3. f
4. a
5. h
6. d
7. i
8. b
9. g

Assessment Task

Suppose you are given the following materials: pencil, transparent tape, water, cubic centimeter of aluminum, large test tube, small sample of granite rock, and metric ruler. If you were told to find the approximate volume of the rock sample with the materials given, you would follow a step-by-step procedure. The steps for performing this task are listed in Column A below, but not in correct order. In Column B, place the letters of the steps in the order that you would carry out the steps in the laboratory.

COLUMN A

a. Place the cubic centimeter of aluminum into the test tube.

b. Place the small piece of granite into the test tube.

c. Pour water into the test tube until it is about half full.

d. Make measurements with the metric ruler.

e. Attach the transparent tape along the edge of the test tube.

f. Mark the starting water level with a pencil on the transparent tape.

g. Measure the volume of the granite.

h. Mark the second water level with a pencil on the transparent tape.

i. Make third, fourth, and fifth marks on the transparent tape with a pencil.

COLUMN B.

1.
2.
3.
4.
5.
6.
7.
8.
9.

MEASURING MASS

OBJECTIVES

Process

11. Demonstrate a procedure for measuring mass.

Concepts

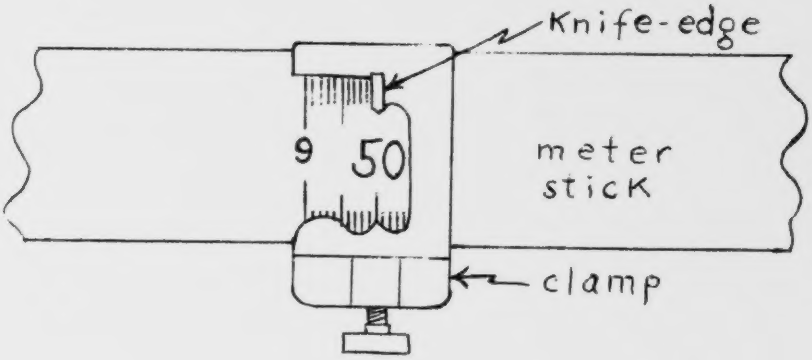
1. When a balance is in a state of equilibrium, the product of mass times distance from the pivot (on one side) equals the product of mass times distance from the pivot (on the other side).

2. If a standard mass is used on one arm of a balance, the mass of another body can be determined by applying Concept 1.

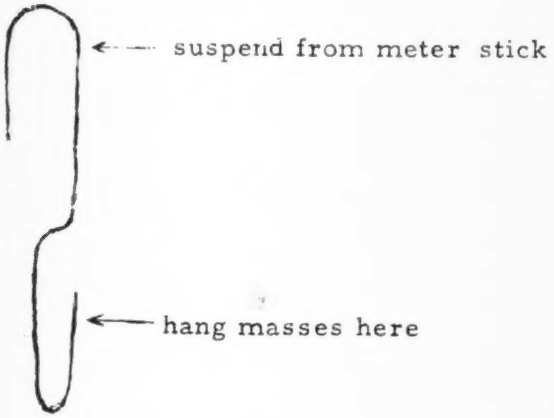
TEACHING SUGGESTIONS

Preparation

1. Place a knife edge on each meter stick as shown below and place the assembly on a knife-edge support.



2. For each group, prepare two paper clips for each meter stick balance as shown below.



3. For each group prepare three pieces of light string, wire, or strong thread to be used for making bundles of 3, 4, and 5 washers.

Procedure

1. Discuss the following ideas prior to the laboratory work:
    - a. The mass of an object is due to the quantity of matter it contains.
    - b. The weight of an object is due to the pull of gravity on its mass.
    - c. If we take an object to the moon its mass does not change.
    - d. Because gravity on the moon is about 1/6 as strong as earth gravity, an object has less weight on the moon than it does on earth.
2. Ask students to feel the heft of a large rock and of a washer. They should have no trouble feeling the difference.
3. Ask students to feel the heft of two sets of washers (one set with 20 washers and one with 21 washers). It is very doubtful that they will be able to feel the difference. Then ask the question, "How could we distinguish between these two sets of washers if each were placed in a similar paper bag"? Stated this way, counting washers is eliminated as a way of distinguishing. Students should be able to state that some kind of weighing instrument is needed.

4. Distribute the materials for Part A. Samples from Planet G could be galena and calcite or any other pair of minerals that have a considerable difference in specific gravity.

5. Students should work in pairs. Allow adequate time for trying various approaches to measuring mass with the apparatus. Do not give advice or assistance unless absolutely necessary. Allow students to confront the problem and find their own solutions. If, after much work, students have been unable to develop a design offer assistance but keep advice minimal.

6. Both equal arm, and unequal arm designs may be developed. A variety of standard masses may also be chosen. If some students devise a sliding weight design capitalize on it during the discussion of Part A.

7. Discuss the results of Part A before going on to Part B. The following ideas should be a part of this discussion:

    a. Some standard of mass is necessary in order to determine an unknown mass.

    b. Equal arm balances require that equal masses be placed on each side of the pivot.

    c. Unequal arm balances require the use of a sliding standard mass and some kind of distance measurement from the pivot to the standard mass.

8. In Part B, the students use the unequal arm design. The work with the meter stick balance should help them to understand the triple beam balance, which will be used to make mass measurements for the rest of the year. Go over the directions for Part B and, as you do so, have the equipment on each student desk for examination.

Responses to Interpretation Questions

Part A

1. The compared results may vary, depending upon the standard unit of mass chosen or the design of the balance.

2. Yes, because students would be able to compare their measurements.

Part B

1. The numbers on any one line in Columns III and IV should be close to the same. (You can see from the calculations that the idea of moments is being used without the term. The calculations are intended to show that the distance the right-hand washer moves has a definite relationship to the mass on the left and its distance from the pivot point.)

2. The slide would have to be moved farther from the pivot. The smaller mass must be moved a larger distance from the pivot point to balance the larger mass.

3. The slide would have to be moved closer to the pivot than it was for any of the other masses. The mass on the right must now balance a mass smaller than any used before, so it must be a smaller distance from the pivot point.

4. The slide on the left would have to be the same distance from the pivot point as the right-hand washer.

1A-18

A MASS-MEASURING DEVICE

OBJECTIVES

Process

11. Demonstrate a procedure for measuring mass.

Concepts

1. A triple beam balance is an unequal arm balance that measures mass.

2. The gram is a standard unit of mass in the metric system.

REFERENCES

Beauchamp et al. Everyday Problems in Science.

Herron et al. Matter, Life, and Energy.

Swartz. Measure and Find Out, Book Two.

TEACHING SUGGESTIONS

Preparation

Prior to the student investigation, obtain the film, "The Triple Beam Balance" and 10 or more one-gram masses. Also, prepare enough materials for the student investigation so the students can work in pairs.

Procedure

1. In Investigation 1A-17, students used an unequal arm balance for measuring mass. Point out that in this investigation they will again be working with an unequal arm balance called the triple beam balance. Show students that both balances are unequal arm balances because of the mass-distance relationship from a pivot point. In Investigation 1A-17, washers were used as a standard unit of mass; now introduce the gram as the metric unit for measuring mass.

If possible, have students handle one gram masses so they can gain some idea of the quantity.

2. Demonstrate the use of the triple beam balance. Since many in the class may have difficulty observing the demonstration, students should have balances at their desks while the teacher is demonstrating. The demonstration should include adjustments of the balance. If different makes or models of balances exist in your school, be certain to make distinctions between them. You may wish to show the film, "The Triple Beam Balance," which illustrates, in steps, the techniques for using the triple beam balance.

3. After students have completed the procedure, they may be given additional practice by doing the activities on Pages 11 and 12 in Measure and Find Out, Book Two. If you wish, have the students read about the difference between weight and mass and the systems used to measure them. This information can be found on Pages 210-214 in Everyday Problems in Science or on Pages 14-18 in Matter, Life, and Energy.

Responses to Interpretation Questions

1. Before beginning to measure the mass, the instrument must be balanced. This means that the product of the mass of the moving part of the instrument itself on one side of the pivot and its distance from the pivot equals the product of the mass of the moving part of the instrument on the other side of the pivot and its distance from the pivot.

2. In most cases, the measurements will be about the same. If discrepancies exist, then perhaps the balance was not read properly or the balance was faulty. Also, of course no measurement is infinitely precise.

Assessment Task

Have students use the triple beam balances to measure the mass of four different objects. If students work in groups of two, each student in the group should have a different set of four objects to measure. For example, student A could measure the mass of a paper clip, a rubber stopper, a 400 ml flask, and a tripod. You will have to measure the mass of one group of sample items prior to the assessment to establish what will be acceptable responses.

1A-19

PUTTING MEASURING SKILLS TO WORK

OBJECTIVE

Process

12. Demonstrate the ability to select the appropriate instrument to measure quantitative characteristics of objects.

TEACHING SUGGESTIONS

Procedures

1. This activity is a laboratory practicum designed so that the student must select measuring devices from those made available and use them to carry out as many measurements as possible.

2. Provide each group with one set of three samples. The samples may be: a) one copper specific gravity cylinder, one brass specific gravity cylinder, and the aluminum rectangular solid from the density kit; or, b) one aluminum specific gravity cylinder, one steel specific gravity cylinder, and the aluminum rectangular solid from the density kit; or, c) any two metal samples having the same dimensions and a third metal in the shape of a rectangular solid.

3. Make a key for your own use so that you can check student results. Get students to use as many of their measuring skills as they can. Do not expect students to identify unknown samples.

4. Make sure that all samples fit into the graduates that you are asking the students to use.

5. Provide paper towels to be used for drying the samples after volume measurements are made.

6. Require students to work independently even though they may share materials.

Expected Results

The length, volume, and mass of each of the samples should be reported by each student. In addition, the width, height, and areas of each of the faces of the rectangular solid should be reported, but it is not necessary that the students find the total area.

Related Activity

As a follow-up to the investigation, the students could make mass and volume measurements of different liquids. In doing this, the students would be faced with the additional task of having to measure the mass of the container prior to finding the mass of the liquid.

DESCRIBING MINERALS

OBJECTIVES

13. Describe the qualitative and quantitative characteristics of objects.

REFERENCES

Namowitz and Stone. Earth Science, The World We Live In (4th ed.). pp. 21-35

Ramsey. Modern Earth Science (Revised 1969). pp. 154-169

Thurber and Kilburn. Exploring Earth Science. pp. 212-215

Zim. Rocks and Minerals. pp. 16-30

TEACHING SUGGESTIONS

Preparation

Use the following 7 mineral samples:

#3, biotite mica
#5, calcite
#9, galena
#17, lodestone or magnetite
#19, obsidian
#22, quartz
#28, willemite

Cautions

Check at the end of each session to make sure the minerals have been returned. Tell the students not to break the samples unless they are instructed to do so.

Procedure

1. Investigations 1A-1 through 1A-10 stressed qualitative observations of rocks and minerals; Investigations 1A-11 through 1A-19 stressed quantitative observations. In this investigation, students make both qualitative and quantitative observations. Because the students have not worked with

the mineral identification techniques for several days, review the definitions of streak, hardness, cleavage, fracture, crystal shape, luster, mass, and volume before they begin to work.

2. Center the discussion on the chart in the student manual. Either draw it on the chalkboard or project it with an overhead projector. Leave enough space to write responses from various groups. Students should recognize from the discussion that several properties can be used to describe one mineral. It is not necessary to stress the names of minerals.

Expected Results

In completing the chart, students may use the material in any order.

Sample No.	Mass	Volume	Streak	Hardness	Cleavage Fracture	Color or Luster	Crystal
3	VARIES WITH SAMPLE		white or none	2.5 to 3	1 side	brown or black	not obvious
5			white	3	3 sides conchoidal	varied	rhombic
9			lead gray	2.5	conchoidal	gray metallic	cubic
17			black	6	conchoidal	black	not obvious
19			none	6	1 side	brown to black; glassy	not obvious
22			none	7		glassy	hexagonal
28			none	4	conchoidal	glassy	not obvious

Responses to Interpretation Questions

CHARACTERISTICS	SAMPLE
Mass	#17, magnetite: heavy; #9, galena: heavy
Volume	(Varies with sample)
Streak	#17, magnetite: black; #9, galena: gray; #5, calcite: white
Hardness	#3, biotite and #9, galena: 2.5; #22, quartz: 7
Cleavage and Fracture	#17, magnetite and #19, obsidian and #22, quartz: conchoidal; #9, galena: uneven; #3, biotite: uneven
Crystal Shape	#9, galena: cubic; #22, quartz: 6 sides
Color or luster	#17, magnetite: black; #9, galena: gray and metallic

1A-21

OTHER TESTS FOR MINERALS

OBJECTIVES

Process

13. Describe the qualitative characteristics of objects.

Concept

Useful characteristics for identifying minerals include flame tests, fluorescence and phosphorescence, and radioactivity.

REFERENCES

Namowitz and Stone. Earth Science (Fourth ed.) p. 25
Zim. Rocks and Minerals. pp. 22-24, 29

TEACHING SUGGESTIONS

Preparation

Obtain the following materials for the demonstration:

- radioactive mineral or source
- magnetic specimen, #17 magnetite
- fluorescent specimens
  - #27 wernerite
  - #28 willemite
- several mineral specimens that show none of the above properties
- bunsen burner
- overhead projector
- magnetic compass, demonstration type
- strontium chloride powder, optional
- copper sulfate powder
- sodium chloride, granular
- nichrome wire loop, #20 or #22
- geiger counter or Nuclear Mini-Lab
- bar magnet
- iron fillings

Cautions

1. During the flame tests have students sitting within a 6-foot radius wear safety glasses. Wear glasses yourself.

2. Do not permit students to handle radioactive materials.

3. Point the mineral light (ultra-violet lamp) away from students.

Procedure

1. Pass a geiger counter first over a radioactive specimen and then over a non-radioactive specimen. Permit the students to record their observations.

   The non-radioactive material does not cause the geiger counter to react. The meter does not move and the clicking, if any, remains constant. The radioactive material causes a definite change in meter readings and the clicks become very rapid and loud.

2. Bring a specimen of magnetite close to a bar magnet. Then pass the magnetite over fine-mesh iron filings. Pass a non-magnetic specimen over the filings. Pass magnetite over a demonstration-type magnetic compass that has been placed on an overhead projector so that the compass needle produces a shadow on the screen. Pass a non-magnetic specimen over the same compass. Have the students record their observations.

   When the magnetite is passed over the iron filings it causes them to move. The non-magnetic specimen has no effect on the filings.

   When the magnetite is passed near a magnetic compass, the compass needle points in the direction of the magnetite. The non-magnetic specimen does not cause the needle to move.

3. Darken the classroom. Turn on the ultra-violet light source and pass it over the fluorescent minerals and some non-fluorescent mineral. Have students record their observations.

   The fluorescent minerals give off a light when subjected to ultra-violet rays. The willemite fluoresces a brilliant green and the wernerite (scapolite) an apricot yellow.

   The non-fluorescent minerals do not react to the ultra-violet rays.

   Mention to the class that some fluorescent minerals react only to particular wave lengths of ultra-violet light.

4. Using a loop of nichrome wire, introduce powdered copper sulfate, sodium chloride, and (optionally) strontium chloride, one at a time, into the flame of a bunsen burner. Have students record their observations.

   The copper sulfate powder produces a bluish-green flame, the sodium chloride a yellow flame, and strontium chloride a deep crimson flame.

   Teachers may include other materials such as magnesium ribbon and potassium in the flame tests. The magnesium flame test is a brilliant white and the potassium is purple.

5. After the demonstrations, issue Zim's Rocks and Minerals and have the students complete the items in the student manual. After checking these, discuss the demonstrations and reading with the class. The following ideas should evolve:

   1. There are many tests that may be used to identify minerals.
   2. Some minerals, but not all, are radioactive.
   3. Some minerals, but not all, are fluorescent when exposed to ultra-violet rays.
   4. Some minerals, but not all, possess magnetic properties.
   5. Some minerals, but not all, exhibit a colored flame when heated.

Expected Results

1. a. geiger counter
   b. ultra-violet rays
   c. blue-green

2. Appropriate groups are:

   fluorescent rocks
   radioactive rocks
   magnetic rocks
   fluorescent and radioactive rocks
   fluorescent and magnetic rocks
   radioactive and magnetic rocks
   rocks exhibiting all of the properties
   rocks exhibiting none of the properties

THE RELATIONSHIP BETWEEN MASS AND VOLUME: PART I

OBJECTIVES

Processes

14. Distinguish among objects on the basis of density.

16. Construct a chart of paired measurements.

17. Construct a chart of paired measurements after first ordering one of the sets of measurements.

18. Distinguish the dependent variable from the independent variable, given a chart of paired measurements.

19. Apply the rule that the scale for the independent variable is ordered on the horizontal axis and the scale for the dependent variable is ordered on the vertical axis.

20. Identify a point on a graph, given a pair of measurements.

Concepts

1. One milliliter of water weighs approximately one gram at room temperature.

2. The chart showing volume of water versus mass of water is an example of an ordered pair of measurements.

3. A measurement of a characteristic of matter is a variable. A measurement that does not depend upon another measurement for its value is an independent variable. A measurement that does depend upon another measurement for its value is called a dependent variable.

4. A graph illustrates the relationship between paired measurements.

5. The ratio of mass to volume for a given substance is constant, if pressure and temperature are constant.

REFERENCES

Swartz. Measure and Find Out, Book Two. pp. 29-34

Thurber and Kilburn. Exploring Earth Science. pp. 10-11

TEACHING SUGGESTIONS

Preparation

Read the student manual carefully. Note that the interpretation should give students assistance in graphing data as well as understanding of the relationship between mass and volume. In this and future work involving the graphing of data, it will be helpful to prepare overhead projection transparencies of grids and of data charts for use during discussions. A glass-marking pencil or grease pencil can be used to write or draw graphs on the transparencies. Marks from these pencils can be easily rubbed off the transparencies so that they can be used with subsequent classes.

Procedure

1. The data from this investigation introduces the concept of density and, at the same time, is used to develop skills in graphing so that students will be able to interpret data on a somewhat higher level than in previous activities.

2. Have the class work out the interpretation section as a separate activity on the day following the laboratory work. The interpretation is being used primarily as a teaching device to introduce the graphing of data.

3. Both the chart of paired measurements (mass and volume of the water) and the grid for graphing should be drawn on a transparency. Enter data from various groups on the chart. Have the class decide on a set of data that seems to be accurate. If there are student measurements that do not agree with the majority of the data, ask for possible explanations. List possible sources of error in measurements. Stress the idea that the mass of 1 ml of water is approximately equal to 1 g. It should be pointed out that this is true only at 4°C, since volume changes with temperature. Because of this, most graduated cylinders are calibrated for room temperature as 20°C.

4. The interpretation is designed to instruct the student in the construction of a line graph. Go over this part carefully with the class. The Swartz reference is helpful if extra work on graphing is needed.

Expected Results

Volume Water in Milliliters	Mass of Water in Grams
10	10
20	20
30	30
40	40
50	50

Responses to Interpretation Questions

1. The mass of the water increased with an increase in volume.

2. 1 g; 100 g

3. a. Mass depends upon volume, because the volumes were already listed in the data chart.
   b. volume
   c. mass

4. a. vertical
   b. horizontal
   c. vertical
   d. horizontal
   e. vertical
   f. 10 ml has a mass of about 10 g.
   g. 40 ml has a mass of about 40 g.
   h. about 25 g
   i. about 35 ml

Acceptable Responses to Assessment Task

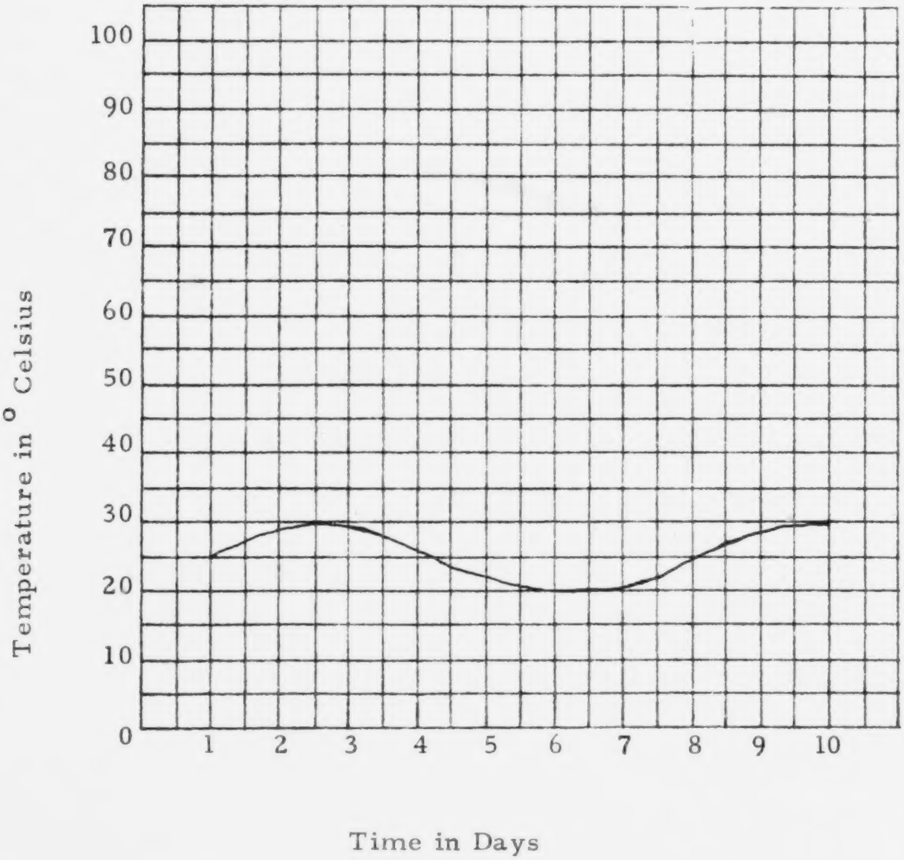
DAY	TEMPERATURE °C
1	25
2	30
3	30
4	26
5	24
6	20
7	20
8	24
9	29
10	30

1. 2, 3, 10
2. 6, 7
3. c
4. independent
5. a

Assessment Task

The following is a graph of data from a weather station. Read the graph and fill in the data chart. Estimate values as closely as you can.

HIGHEST TEMPERATURES OVER A 10 DAY PERIOD



DAY	TEMPERATURE, °C
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

1. On what 3 days was the temperature the highest?

2. On what 2 days was the temperature the lowest?

3. On the fifth day, the temperature was between which numbers?

   a. 15° - 20°   c. 20° - 25°
   b. 25° - 30°   d. 25° - 30°

4. Time in days is the (dependent, independent) ____________ variable.

5. What was the greatest range (difference between highest and lowest temperatures) during the 10-day period? Circle the letter in front of your choice of an answer.

   a. 10°   b. 100°   c. 5°   d. 50°

RELATIONSHIP BETWEEN MASS AND VOLUME: PART II

OBJECTIVES

Processes

15. Distinguish among objects on the basis of physical properties.
17. Construct a chart of paired measurements after first ordering one of the sets of measurements.
19. Apply the rule that the scale for the independent variable is ordered on the horizontal axis and the scale for the dependent variable is ordered on the vertical axis.
20. Identify a point on a graph, given a pair of measurements.
21. Construct a line graph of ordered pairs.
22. Construct a statement that describes a set of data.
23. Construct one or more ideas from a table or graph.
24. Construct one or more ideas from a set of observations.
25. Identify the data that supports an idea.

Concepts

1. The mass-to-volume ratio is different for different liquids. This ratio, mass divided by volume, $\left(\frac{M}{V}\right)$, is called density.
2. Density is a property of matter that is useful in the identification of materials.

REFERENCES

Blanc et al. Modern Science 3. pp. 137-143

Brandwein et al. Matter, Its Forms and Changes. pp. 154-156

Swartz. Measure and Find Out, Book Two. pp. 29-34, 61-64

Thurber and Kilburn. Exploring Physical Science. pp. 9-16

TEACHING SUGGESTIONS

Preparation

The three unknown liquids to be used in this investigation are methyl alcohol, water, and magnesium sulfate (Epsom salts). Prepare the magnesium sulfate solution by dissolving at least 20 g of the salt in 100 ml of tap water. The resulting solution is a clear, odorless liquid, 50 ml of which has a mass of about 57 g.

Caution

Tell students not to taste any of the materials. Methyl alcohol is a poison.

Procedure

1. Give each group of students three beakers. Each of the beakers should contain one of the three samples. Stress the need for accurate and consistent measurement. Review the method of reading the meniscus of the liquid in the graduated cylinder. Encourage students to repeat the procedure for each liquid to check the consistency of their measurements. There is sufficient room in the data charts to provide for several trials, if time permits.

2. Use the interpretation questions as a discussion guide. From Question 5, the students should see another identifiable characteristic of matter. This characteristic is called density and is the ratio of mass to volume for a given substance. Sometimes it is useful to think of density as the amount of matter packed into a given volume of material. A ratio is a way of comparing one measurement to another. If one number is two times the second number, the ratio of the first number to the second number is two.

   For example,

   If a mass of 12 grams has a volume of 10 ml, the ratio of mass to volume is 12 g to 10 ml = $\frac{12\text{ g}}{10\text{ ml}}$ = 1.2 g / ml density

   If a mass of 10 grams has a volume of 15 ml, the ratio of mass to volume is 10 g to 15 ml = $\frac{10\text{ g}}{15\text{ ml}}$ = 0.675 g / ml density (less than one)

3. During the discussion, you may introduce a demonstration to show how various liquids float on each other. Carefully pour the liquids into a graduated cylinder in the following order: mercury (13.6), water (1.0), oil (9), alcohol (.8), and gasoline (.66). Color the alcohol and water with food coloring.

Responses to Interpretation Questions

1. The independent variable is volume in ml; it is plotted on the horizontal axis.

2. No; Liquid 1 is heavier than Liquid 2, and Liquid 2 is heavier than Liquid 3.

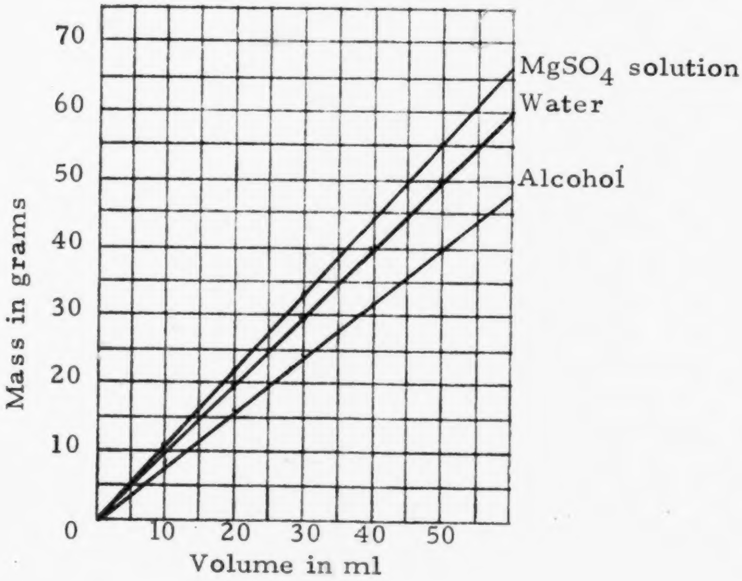
3. Liquid 2; the number of ml is approximately equal to the mass in grams at each measurement. This was also true for water in Part I.

4. The units are Liquid 1 = 1.1, Liquid 2 = 1.0, Liquid 3 = .8. The units are in grams/milliliter.

5. I could use this information to help identify unknown rocks and minerals.

Expected Results

The graph should look approximately as follows:



Volume in Milliliters

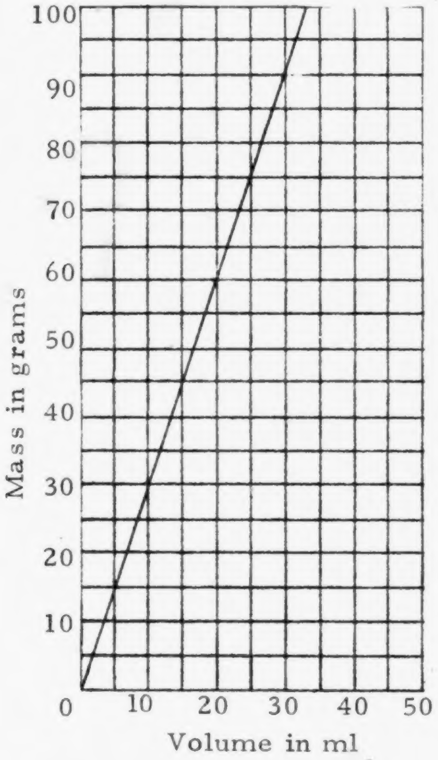
Liquid 1 -
$MgSO_4$ solution
Density approx.
1.1g/ml

Liquid 2 -
Water
Density approx.
1.0 g/ml

Liquid 3 -
Alcohol
Density approx.
0.8 g/ml

Assessment Task

A student prepared a green liquid using his chemistry set at home. He had the following graph of the volume-mass relationships of the substance.



1. Which set of measurement (mass or volume) is the dependent variable?

2. How does this line graph of mass-versus-volume differ from the graph you observed for water?

3. What is the mass of 10 ml of the green liquid? 30 ml? 25 ml?

4. The ratio of the mass of water to its volume is one. This ratio of one is called the density of water or its mass per unit volume.

$$\text{Density} = \frac{\text{Mass in Grams}}{\text{Volume in Milliliters}}$$

What is the density of the green substance?

Acceptable Responses to Assessment Task

1. mass

2. The line on this graph rises at a greater rate. It has a steeper slope. The mass increases at a greater rate than that of water.

3. 30 g, 90 g, 75 g

4. 3 g/ml

1A-23A

OPTIONAL ASSESSMENT TASK

This material can be used either as extra practice in measuring and graphing for average ability students or as an assessment task for high ability groups. It includes the relationships of the diameter to the circumference of a circle, the side of a square to its area, and the edge of a cube to its volume. It can be used anytime after Activity 1A-23 has been completed. The extra graph grids printed at the back of the student manual can be used for this work.

Acceptable Responses

Part A

1.

Circle Number	Diameter in cm	Circumference in cm
1	2	6.3
2	3	9.5
3	4	12.6
4	5	15.8
5	6	18.8
6	7	22.0
7	8	25.1

2. See Graph 1.

Part B

1.

Square Number	Side Length in cm	Area in cm^2
1	1	1
2	2	4
3	3	9
4	4	16

2. See Graph 2.

Part C

1.

Cube Number	Edge Length in cm	Volume in cm^3
1	1	1
2	2	8
3	3	27
4	4	64

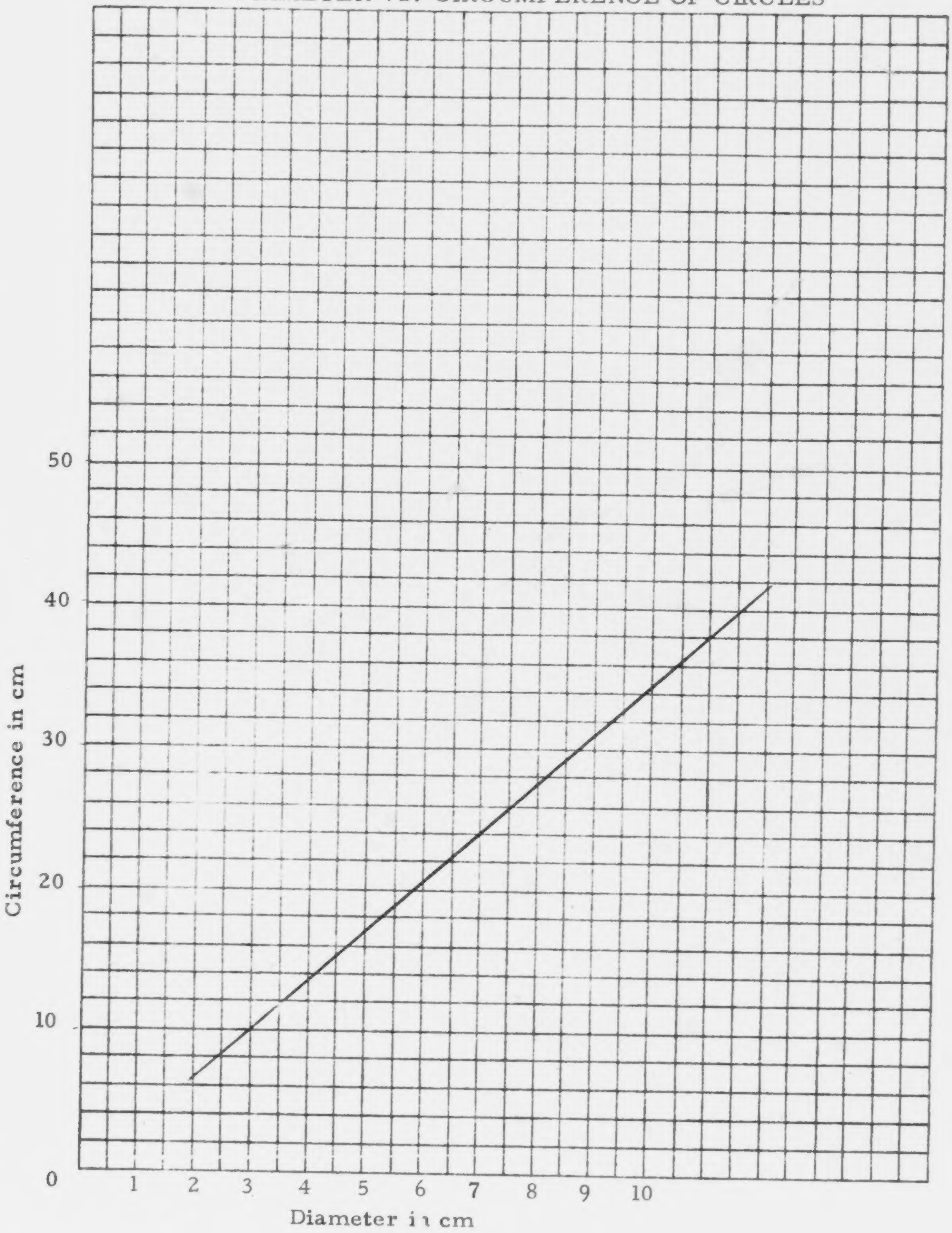
2. See Graph 3.

Answers to Multiple Choice Questions

1. b
2. b
3. d
4. c
5. b
6. a
7. c
8. c
9. a
10. d

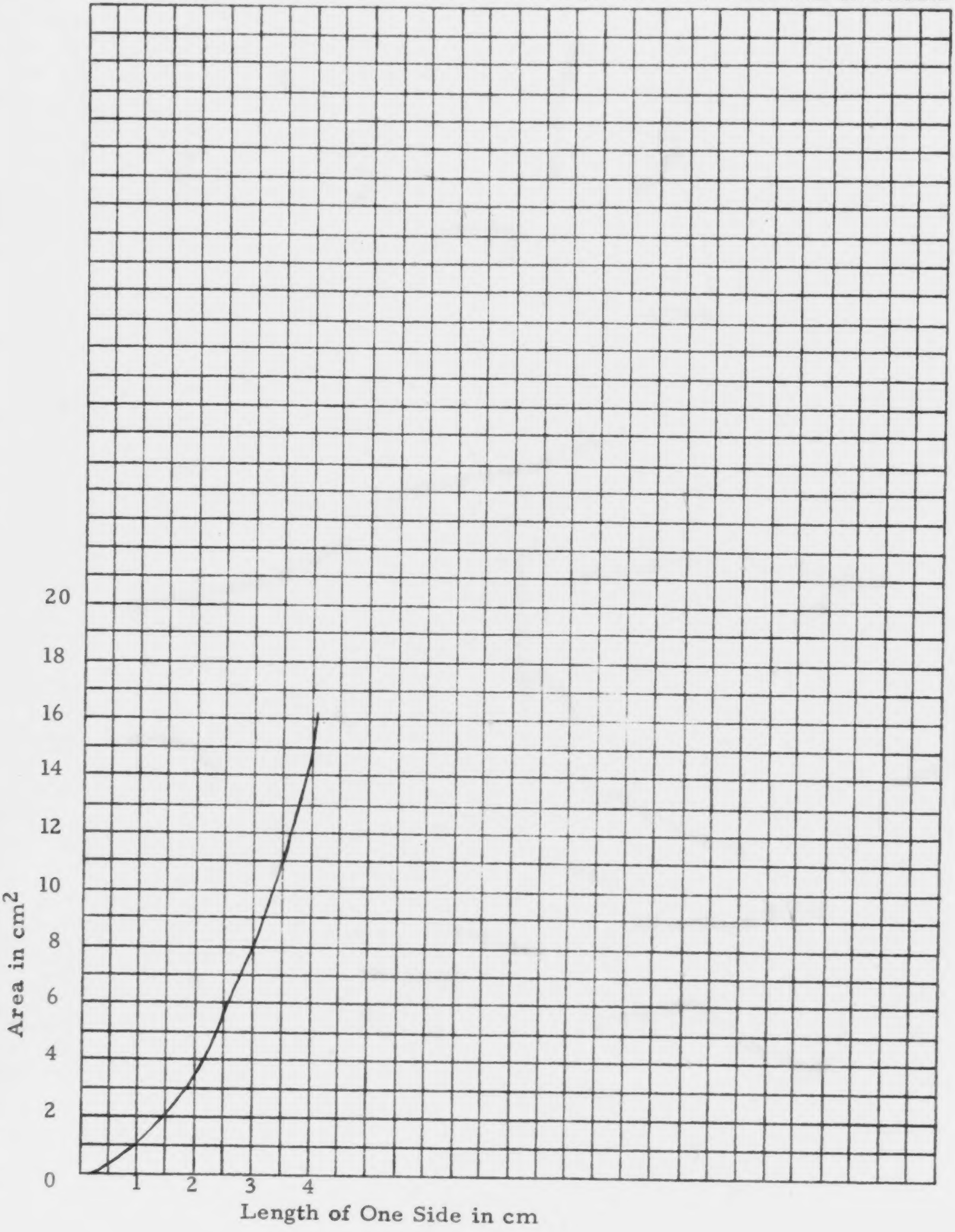
GRAPH 1

DIAMETER VS. CIRCUMFERENCE OF CIRCLES



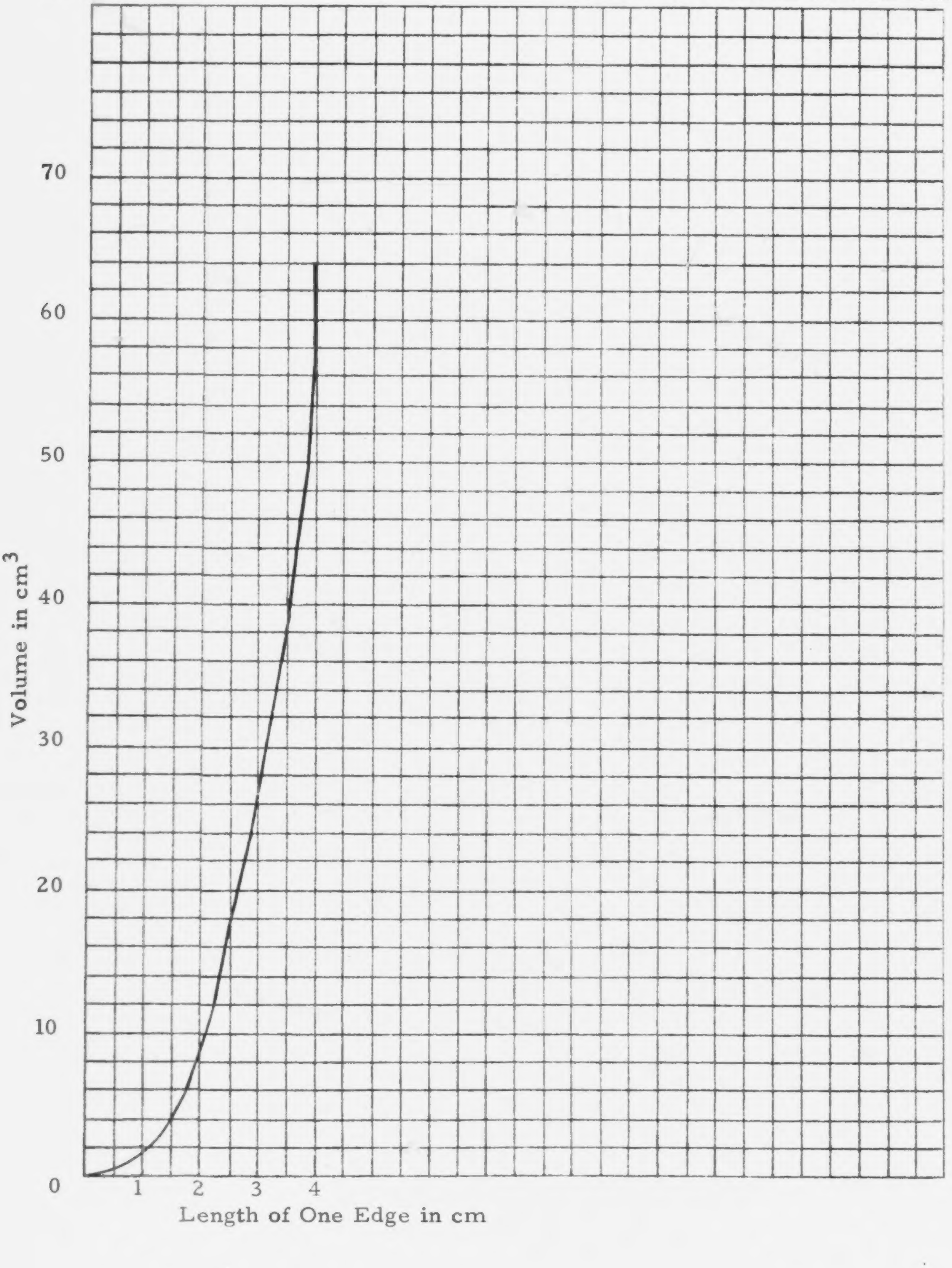
GRAPH 2

CHANGES IN LENGTH OF SIDE OF A SQUARE VS. CHANGE IN AREA



GRAPH 3

CHANGES IN LENGTH OF AN EDGE OF A CUBE VS. CHANGE IN VOLUME

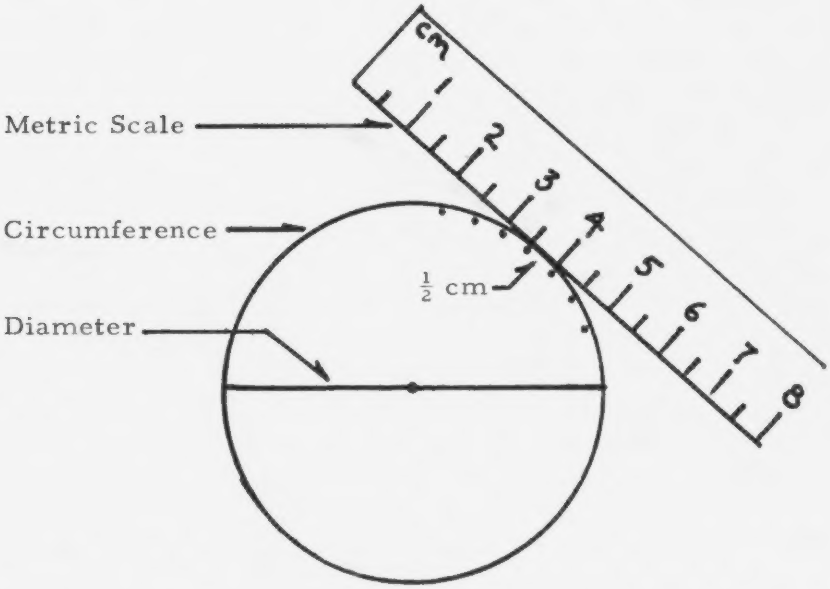


MEASURING AND GRAPHING

Part A. Circles

You will measure two dimensions of several circles and construct a graph to show the relationship between those two measurements.

One of the measurements is the circumference. The circumference is the distance around the circle. Because the circumference is a curved line, it is necessary to measure the circumference in very small pieces at a time. Each little piece of the circumference is close to being a small straight line. Measure the circumference and diameter using your metric scale. You will be able to get a more accurate measure of the circumference if you measure it in ½ cm (or 5 mm) steps, as shown in the diagram below.

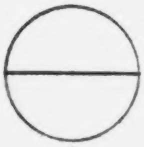


The other measurement is the diameter. The diameter is a line connecting points that are opposite to each other on the circumference of a circle. The center of the circle is on the diameter.

Remember to express the diameter and circumference in the same units. Both must be expressed either in centimeters or millimeters.

Complete the following steps:

Part A. Circles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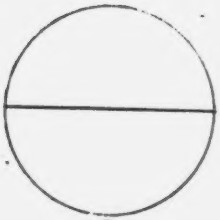
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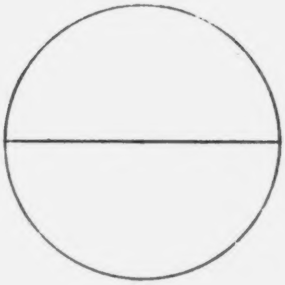
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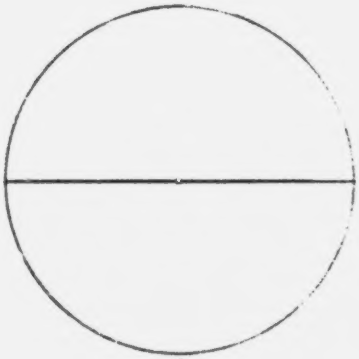
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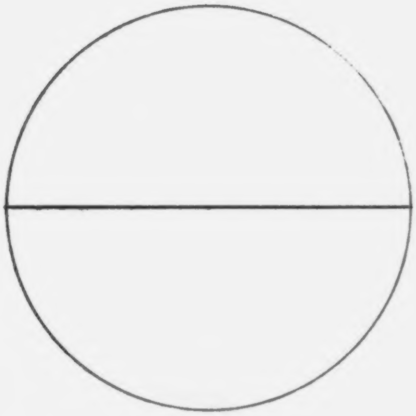
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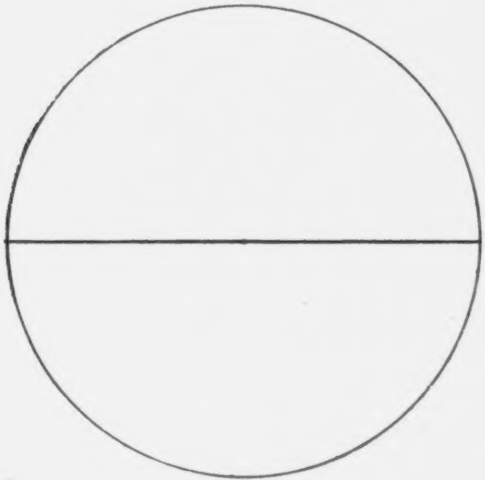
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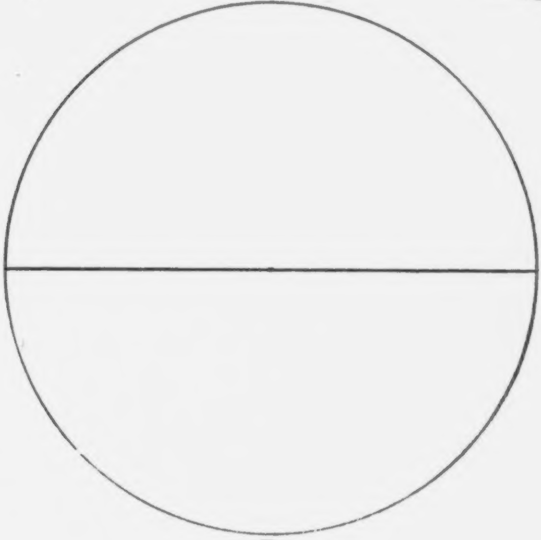

7

1. Construct a chart for recording the diameter and circumference as paired measurements. You need 7 lines on the chart because there are 7 circles to be measured.

2. Measure to the nearest 0.1 cm the diameter and circumference of each circle on the next page. Enter this data on your chart.

3. Construct a graph of the paired measurements. Use the diameter as the independent variable.

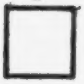
4. State a number which shows the relationship or ratio between the diameter and the circumference of circles. Show how you obtained this number.

Part B. Squares

Measure the sides of the squares below to the nearest 0.1 cm. Find the area of each square. Then calculate the area of each square. Construct a chart of paired measurements for the length of a side of each square versus its area.

From your chart of sides versus areas, construct a graph of these paired measurements. Let the length of a side be the independent variable.

1



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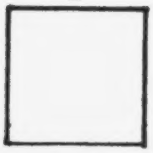

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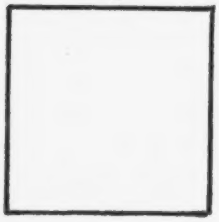

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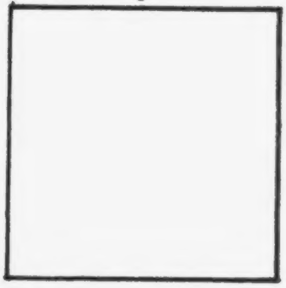
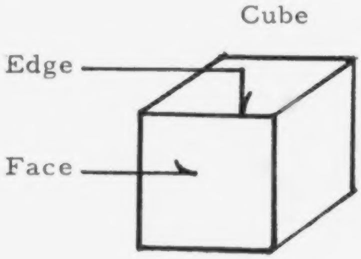


Part C. Cubes

Imagine the squares in Part B to be faces of cubes. Find the volume of each cube. Construct a chart of the lengths of the edges versus the volumes. Construct a graph of these paired measurements. You will choose the independent variable.



After you have completed work on all three graphs, answer the following questions. Choose the letter of the correct answer and place it in the blank to the left of each question.

____ 1. What is the greatest difference between the graph in Part A and the graph in Part B?

- a. The graph in Part A is more curved than the graph in Part B.
- b. The graph in Part A is less curved than the graph in Part B.
- c. The graph in Part A is a graph of ordered pairs.
- d. There is no great difference between the graphs.

____ 2. What is the greatest difference between the graphs in Part B and Part C?

- a. The graph in Part B is more curved than the graph in Part C.
- b. The graph in Part B is less curved than the graph in Part C.
- c. The graph in Part C is a straight line.
- d. The graph in Part B is a straight line.

____ 3. What do the data in Part A indicate?

- a. The diameter of a circle is longer than the circumference.
- b. The diameter of a circle is about 3 times longer than the circumference.
- c. The circumference of a circle is about 1/3 as long as the diameter.
- d. The circumference of a circle is about 3 times the length of the diameter.

____ 4. What do the data in Part B indicate?

- a. The area of a square is always 2 times the length of one side.
- b. The length of one side of a square is always 1/4 the area of the square.
- c. As one side of a square is increased, the area of the square increases more than the length of the side increases.
- d. The length of a side of a square increases more than the area of a square increases.

____ 5. What do the data in Part C indicate?

- a. The volume of a cube is always 4 times the length of one edge.

b. As one edge of a cube is increased, the volume of the cube increases much more than the increase in the length of the edge.

c. The volume of a cube increases more than the area of one face of the cube when there is an increase in one edge.

d. The edge of a cube increases no more than the increase in the volume of the cube.

____ 6. From your graph in Part B, estimate the area of a square having a side of 2.5 cm. Choose the answer that best best represents your estimate.

a. 6.3 cm^2 b. 5.0 cm^2 c. 12.5 cm^3 d. 7.0 cm^2

____ 7. From your graph in Part B, estimate the length of a side of a square having an area of 12 cm^2. Choose the answer that best represents your estimate.

a. 6.0 cm b. 3.8 mm c. 3.5 cm d. 2.5 cm

____ 8. From your graph in Part C, estimate the volume of a cube having an edge of 2.5 cm. Choose the answer that best represents your estimate.

a. 7.5 cm^3 b. 6.3 cm^3 c. 15.6 cm^3 d. 20 mm^3

____ 9. From your graph in Part C, estimate the length of an edge of a cube having a volume of 12 cm^3. Choose the answer that best represents your estimate.

a. 2.3 cm b. 4 cm c. 2.6 mm d. 2.9 cm

____ 10. From your graph in Part C, estimate the length of the edge of a cube having a volume of 70 cm^3. Choose the answer that best represents your estimate.

a. 5.5 cm b. 4.9 cm c. 5.3 cm d. 4.3 cm

DETERMINING THE DENSITY OF SOLIDS

OBJECTIVES

Processes

15. Distinguish among objects on the basis of physical properties.

20. Identify a point on a graph, given a pair of measurements.

23. Construct one or more ideas from a graph.

Concepts

1. A submerged solid displaces a volume of water equal to the volume of the solid.

2. The density of an irregular solid can be found by dividing its mass by the volume of water it displaces.

REFERENCES

See 1A-23.

TEACHING SUGGESTIONS

Preparation

Obtain the needed rock samples. Be sure that they fit easily into the graduated cylinders. Sample #22 is quartz; #57 is pumice. The pumice is an igneous rock, the chemical composition of which is similar to granite. The difference is that the pumice has been blown full of holes by volcanic gases. The pumice, therefore, contains many air spaces, which allow it to float. It should be interesting to see if students use the dissecting needle or similar object to push the pumice below the surface of the water to measure its volume displacement.

Caution

Before the laboratory period, demonstrate a method for placing the samples into the graduated cylinder in such a way that water does not splash out and the sample does not hit the bottom of the cylinder with enough force to break the glass.

Procedure

1. Students have determined the densities of various liquids. Introduce the investigation by asking them what information is required to find the density of a solid material.

2. Discuss methods by which the volume of a solid can be determined. Review the methods used in 1A-15 and 1A-16 for determining the volume of a solid object both in cubic centimeters and, by the displacement of water, in milliliters.

3. If necessary, review the calculation for determining density.

$$\text{Density} = \frac{\text{Mass in Grams}}{\text{Volume in Milliliters}}$$

4. Include in the discussion that follows the laboratory work all of the interpretation questions. Students should realize that cubic centimeters and milliliters are equal.

5. Ask students about the validity of the density calculation they made for pumice. They should see that a gas is inside the pumice and the density of the gas contributed to the result.

Expected Results

1.

Object	Volume in Cubic Centimeters	Volume in Milliliters	Mass in Grams	Density $\left(\frac{M}{V}\right)$
Aluminum Cube	2.04	2.04	5.6	2.7
Aluminum Slab	12.3	12.3	33.2	2.7
Steel Ball	1.1	1.1	8.5	7.7
Sample #22	Varies	Varies	Varies	2.7
Sample #57	Varies	Varies	Varies	Less than 1

2. The volume of the $\frac{1}{2}$-inch aluminum cube is 1.27 x 1.27 x 1.27 cm, which is about 2.04 cm^3.

3. The volume of the aluminum slab is 7.6 x 2.54 x .64 cm, which is about 12.3 cm^3.

   These volumes are the same in milliliters.

4. Able students should be able to check the volume of water displaced by the sphere with the formula for the volume of a sphere.

   The volume of the steel sphere in cubic centimeters is $4/3\ \pi r^3$.

   Explain the value of "π" as being 3.14, the value which was determined for the relationship between the circumference and the diameter of a circle in 1A-23A.

   The $\frac{1}{2}$-inch sphere has a diameter of 1.27 cm and a radius of about 0.63 cm.

   The volume in cm^3 is: 4/3 x 3.14 x 0.63 x 0.63 x 0.63 cm = 1.1 cm^3 = 1.1 ml, approximately.

5. The volumes of the rock samples will vary. Students will have difficulty in trying to measure the dimensions of the irregular rock samples with the metric scale. However, they should see that since the volumes in cc and ml for the aluminum samples were equal, this should also be true for the rock samples. Since pumice floats, students may encounter a problem in finding its volume by displacement. The dissecting needle can be used to push the pumice below the water surface to get its displacement.

Responses to Interpretation Items

1. No, the volume of the steel ball and the rocks could not be found by measuring with a scale. Sample #57 floated in the water surface instead of sinking.

2. The dissecting needle should be used to push rock #57 under the surface of the water.

3. Undoubtedly, some mistakes are made in reading the scales of the graduated cylinder and the balance. There could also be mistakes in multiplying.

4. The steel ball and the rocks do not have straight sides. You need a formula for the steel ball.

5. The volume in cc and ml are the same.

6. Mass

7. Point 3

8. Mass = 13.5 g; volume = 5 ml; density = $\frac{13.5 \text{ g}}{5 \text{ ml}}$ = 2.7 g/ml.

9. Yes, all $\frac{M}{V}$ for points 1, 2, and 4 equal about 2.7 g/ml.

10. The aluminum cube, the aluminum slab, and Sample #22

THE DENSITY OF AIR

OBJECTIVES

Processes

15. Distinguish among objects on the basis of physical properties.

Concepts

1. The density of air can be determined by methods similar to those used in determining the density of solids and liquids.

2. Air is a mixture of gases. The density of a gas is generally much less than that of a liquid or a solid.

3. Floating objects have a density less than that of the liquid on which they are floating.

REFERENCES

Thurber and Kilburn. Exploring Earth Science. p. 35

Educational Services Inc. Introductory Physical Science, Teacher's Guide. pp. 54-56; Student Guide. pp. 29-31

TEACHING SUGGESTIONS

Preparation

Obtain the following materials needed for the demonstration:

vacuum pump and hose attachment
weight-of-air cylinder
triple beam balance

If available, use an electric vacuum pump, but a hand pump is satisfactory. If a weight-of-air cylinder is not available, you can use a volleyball or a basketball with a slight variation in the procedure.

Procedure

1. Attach the hose between the vacuum pump and the weight-of-air cylinder. Open the valve on the cylinder, switch on the pump, and allow the pump to draw a vacuum for about one minute.

2. While the pump is still running, close the valve on the cylinder. Then turn off the pump.

3. Have one or two students come up to the demonstration table to aid in observing and recording the mass measurements. Have one student read the balance. Have the other student record the data on the chalk board.

   The following data should be recorded:

   mass of air-filled cylinder ____________ g
   mass of evacuated cylinder ____________ g
   mass of air in cylinder ____________ g
   diameter of cylinder ____________ cm
   radius of cylinder $(\frac{d}{2})$ ____________ cm
   height of cylinder ____________ cm
   volume of cylinder, πr^2h, (and therefore the air in the cylinder) ____________ cm^3
   density of the air ____________ g/cm^3

4. Place the evacuated (lower pressure) air cylinder on the balance. Record the weight of the "empty" cylinder.

5. Leave the cylinder on the balance. Open the valve on the cylinder. As air rushes in, the students should observe the change in mass of the cylinder as the balance tips. Record the new mass. If a volleyball or basketball is used, pump air into the ball first, record the mass, and then allow air to escape.

6. Have the class compute the mass of the air in the cylinder.

7. At this point, discuss the method by which the volume of the cylinder or ball can be computed. If a ball is used, the formula for its volume is $4/3\ \pi r^3$. The volume of the cylinder can be roughly computed by the formula πr^2h. If necessary, briefly discuss the meaning of π. The πr^2 is the area of the cylinder. The height of the cylinder gives the number of circular bases that can be piled up to make the cylinder. This formula relates to LxWxH for a regular solid where LxW and πr^2 are the areas of the bases. The calculations can be checked roughly by measuring the amount of water displaced by the cylinder, using a large, graduated beaker of water. These calculations need not be exact. The density of air under 1 atmosphere of pressure is about .00129

g/ml = 1.29 g/l. One liter of air weighs about 1.29 grams. Remind students that air has been compressed into the small cylinder by the vacuum pump.

8. The Introductory Physical Science reference describes a laboratory investigation of the density of a gas that is an excellent student laboratory activity. This can be used with more able students instead of the above teacher demonstration. This reference gives a method in which the carbon-dioxide gas from an Alka-Seltzer tablet is used. Be sure to discuss the conservation of matter prior to the investigation.

9. Have the class discuss sources of error in the demonstration. Discuss the method used in the Thurber and Kilburn reference. If materials are available, demonstrate this method also.

10. Discuss the interpretation questions. The concept of floating illustrated by the pumice sample in 1A-23 can be reviewed here.

11. Ask students how they might be able to find the mass of an object given the volume and the density or how they might determine the volume given the mass and the density.

$M = VD; \qquad V = \frac{M}{D}$

Responses to Interpretation Questions

1. Answers will vary; see procedures above.

2. This value should be much less than one.

3. Objects filled with air can have a total combined density less than that of water. Objects with a density less than that of water will float on water.

Acceptable Responses to Assessment Task

1. biotite = 3.0; quartz = 2.65; feldspar = 2.5; magnetite = 5.2; calcite = 2.7

2. a. 10 g   b. 10 g

3. a. 1.85 cc

Assessment Task

1. A student measured the following volumes and masses for several mineral samples. Find the density of each sample.

Mineral	Volume	Mass	Density
Biotite Mica	5 ml	15 g	
Milky Quartz	.1 liter	.265 kg	
Feldspar	10 ml	25 g	
Garnet	12 ml	48 g	
Magnetite	10 ml	52 g	
Calcite	20 ml	54 g	

2. From the formula for density, $\text{Density} = \frac{\text{Mass}}{\text{Volume}}$,

it follows that Mass = Density x Volume. Given the following volumes and densities, determine the mass of the materials.

a. Volume = 5 ml
Density = 2 g/ml
Mass = ______ g

b. Volume = 100 cc
Density = .1 g/ml
Mass = ______g

3. Which of the following is the volume of an object having a density of 2.7 g/cc and a mass of 5 g?

a. 1.85 cc b. 13.5 cc c. .54 ml d. 5.4 cm^3

1A-26

SPECIFIC GRAVITY

OBJECTIVES

Process

14. Distinguish among objects on the basis of specific gravity.

Concepts

1. Specific gravity is the ratio of the weight of an object to the weight of an equal volume of water. It tells how many times heavier an object is than an equal volume of water.

2. Any object having a specific gravity greater than one will sink in water. Any object having a specific gravity less than one will float in water.

3. If specific gravity is greater than one, it approximately equals the density of the object when both were measured in grams per cubic centimeter.

REFERENCES

Namowitz and Stone. Earth Science, The World We Live In (4th ed.). pp. 24-25

Zim. Rocks and Minerals. p. 19

Herron and Palmer. Matter, Life, and Energy. pp. 98-100

Blanc, et al. Modern Science 3. pp. 138-144

Thurber and Kilburn. Exploring Earth Science. p. 215

TEACHING SUGGESTIONS

Preparation

Prepare for each student group a set of the following materials:

Sample # 3 - mica
Sample #22 - quartz, milky
Sample # 7 - feldspar
Sample #10 - garnet
Sample #17 - magnetite

Sample # 5 - calcite
spring scales, 500 g,
or
triple beam balance
beaker, 250 ml

Procedure

1. Distribute student materials. Draw a facsimile of the student chart on the board.

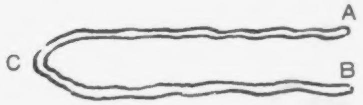
2. Using a specimen that is not in the student kit, demonstrate:

    a. one method of tying a specimen.
    b. how to determine the weight of a specimen in air, using both the spring scale and triple beam balance. Record measurements on the chart.
    c. how to determine the weight of a specimen in water, using both the spring scale and the triple beam balance. Record measurements on the chart.

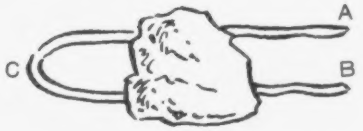
Illustrations of the three procedures follow.

A Method of Tying a Rock

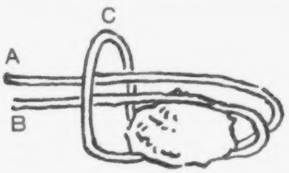
Lay a piece of string on the table.



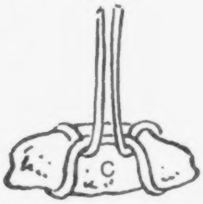
Place specimen on string.



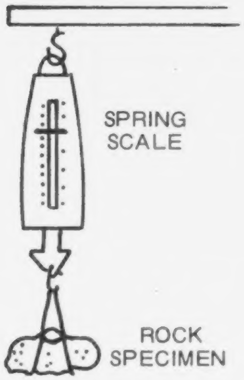
Draw ends A and B through C until specimen is firmly in position.

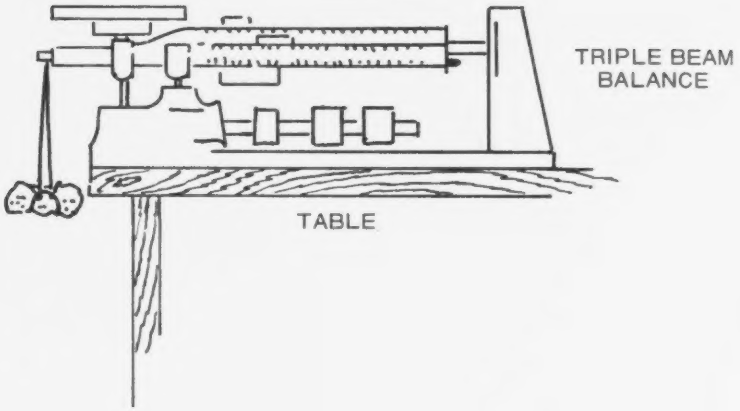


Tie ends A and B together.

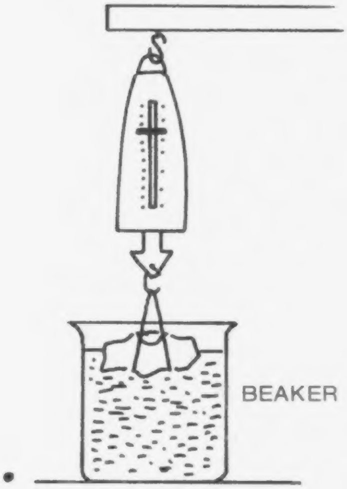


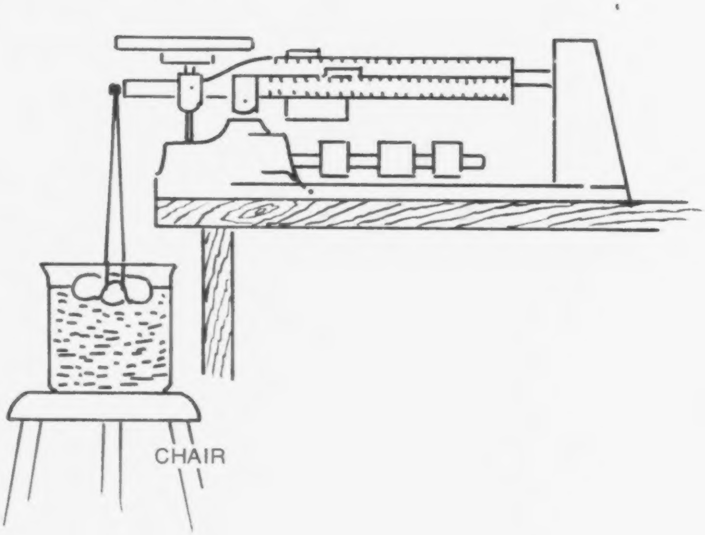
Determining the Mass of a Specimen in Air


SPRING SCALE
ROCK SPECIMEN


TRIPLE BEAM BALANCE
TABLE

Measuring a Specimen in Water





3. Have the students complete Procedure Items 1 and 2 in their manuals.

4. Conduct a class discussion relating to the data collected by the students. The formula for finding specific gravity should evolve from the discussion.

$$\text{Specific Gravity} = \frac{\text{Weight of Sample in Air}}{(\text{Weight of Sample in Air}) - (\text{Weight of Sample in Water})}$$

Compute the specific gravity of the demonstration specimen.

5. Have students compute specific gravities of their samples.

6. Have students complete the interpretation items.

7. Discuss interpretation items with the class. Make sure the students are aware of the correct usage of the terms weight and mass. The term mass applies to the quantity of matter contained in an object. Mass is not affected by a change in position. The term weight is used to indicate the gravitational pull exerted upon an object. The weight of an object varies according to its position with respect to other objects.

Expected Results

The calculated specific gravities should approximate the densities given in the last column of the chart in the student manual. Acceptable ranges are:

# 3	2.5 - 3.5
#22	2.15 - 3.15
# 7	2.0 - 3.0
#10	2.9 - 4.7
#17	4.7 - 5.7
# 5	2.2 - 3.2

Responses to Interpretation Questions

1. The density and specific gravity for any sample are numerically the same.

2. No matter where an object is located, its mass remains unchanged. Weight, on the other hand, does change. In this investigation the objects were immersed in water where the weight, as measured by the scale or balance, was apparently reduced.

3. #17, #10, #3, #5, #22, #7

4. #17, #10, #3, #5, #22, #7

5. The lists are identical.

Assessment Task

Using the data below, determine the specific gravity of four rocks.

Rock	Weight in Air	Weight in Water
1	5 grams	3 grams
2	8 grams	6 grams
3	10 grams	5 grams
4	6 grams	4 grams

Acceptable Responses to Assessment Task

$$\text{sp. g.} = \frac{5 \text{ grams}}{5 \text{ grams} - 3 \text{ grams}} = \frac{5 \text{ grams}}{2 \text{ grams}} = 2.5$$

$$\text{sp. g.} = \frac{8 \text{ grams}}{8 \text{ grams} - 6 \text{ grams}} = \frac{8 \text{ grams}}{2 \text{ grams}} = 4.0$$

$$\text{sp. g.} = \frac{10 \text{ grams}}{10 \text{ grams} - 5 \text{ grams}} = \frac{10 \text{ grams}}{5 \text{ grams}} = 2.0$$

$$\text{sp. g.} = \frac{6 \text{ grams}}{6 \text{ grams} - 4 \text{ grams}} = \frac{6 \text{ grams}}{2 \text{ grams}} = 3.0$$

Students should solve 3 of the 4 problems correctly.

1A-27

DISTINGUISHING SIMILAR ROCKS

OBJECTIVES

Processes

15. Distinguish among objects on the basis of physical properties.

24. Construct one or more ideas from a set of observations.

Concepts

1. Different rocks or minerals may be similar in appearance.

2. Rocks or minerals that are similar in appearance can be distinguished by investigating their quantitative properties.

REFERENCE

Zim. Rocks and Minerals.

TEACHING SUGGESTIONS

Preparation

1. Each group of students should have one of each of the materials listed in the student manual, except for the geiger counter and the ultra-violet lamp. Set up two stations at well-separated locations where students can test for radioactivity and fluorescence.

2. Be sure to test the marble specimens for effervescence. Although most marble will effervesce in weak acid, some specimens may require a stronger acid solution. The acid usually affects the marble along a scratch made in the specimen; at least a few bubbles should be evident under a hand lens. Strengthen the hydrochloric acid solution if necessary.

Cautions

The acid solution is strong enough to cause eye damage and skin irritation. Have the students in the group who perform the acid tests wear goggles. Students should not look directly at the ultra-violet lamp.

Procedure

1. Introduce this investigation by showing samples #53 and #54 side by side. Tell the students that one of the samples is a rock called quartzite (#54), the other a rock called marble (#53). Though the two look alike, they can be distinguished when their properties are compared.

2. Explain that calcite is a mineral contained in one of the rock specimens. Demonstrate the use of the medicine dropper to place the acid, one drop at a time, on a specimen; but do not place it on any of the specimens used in this investigation.

3. Have one student from each group take specimens to the geiger counter and the ultra-violet lamp stations.

4. Summarize the work by listing the various similar and dissimilar properties of quartzite and marble on the chalkboard. There will probably be some disagreement among students. For example, effervescence will not be easily observed when acid is placed on the marble, or the specific gravities of both may not have turned out to be alike. It should be pointed out that perhaps more trials in testing each of the properties or that more careful measurement would have promoted more agreement among students. Make sure that students realize that their discrepancies arose because they distinguished between the rock specimens on the basis of only a few properties.

Expected Results

Specimen Number	Color	Streak	Luster	Hardness	Specific Gravity	Cleavage Fracture	Other
53	white	white	glassy	3-5	2.7	uneven fracture	"fizzes" in acid
54	white	white	glassy	7	2.7	uneven fracture	

Responses to Interpretation Items

1. The description of each rock sample should contain all of the information in the data chart, plus some description of the size of the grains and the texture of each rock.

2. The similar properties are: color, streak, luster, specific gravity, fracture, and size of grains in each rock. Neither rock is fluorescent or radioactive.

3. The dissimilar properties are hardness and the kind of minerals contained in each rock. Marble contains calcite as shown by the acid test.

IA-28

NAMING MINERALS

OBJECTIVES

Processes

25. Identify the data that supports an idea.

26. Distinguish whether or not an idea is supported.

27. Order a set of ideas from least to most probable.

Concepts

1. A hypothesis is a "first idea" about an answer to a problem.

2. A hypothesis is based on available data.

3. A mineral specimen can usually be identified only after a wide range of qualitative and quantitative observations have been made.

REFERENCES

Zim. Rocks and Minerals.

TEACHING SUGGESTIONS

Preparation

Each student group should have each of the materials listed in the student manual except the ultra-violet lamp and the geiger counter. Set these up at separate stations. The following minerals are to be included in the set to be investigated by each student group:

21 - quartz crystal
9 - galena
28 - willemite
26 - sulfur
13 - halite
3 - biotite
14 - hematite
17 - magnetite
10 - garnet
7 - feldspar
4 - calcite
23 - talc

Caution

Remind students about the proper handling of acid and of the ultra-violet lamp.

Procedure

1. More than one class period may be needed for the work of this investigation.

2. As an introduction discuss the definition of a hypothesis. Refer students to the introductory paragraph in the student manual. Be sure to relate the purpose to the processes and concepts.

3. As a goal for the class set up some number of minerals to be correctly identified. The goal should vary among classes. For example, in a very able class, you might set as a goal the correct identification of 10 out of 12 minerals in the set.

4. On the chalkboard compile the first and second hypotheses for each mineral. Select a spokesman from each group to explain the hypotheses in terms of the evidence gathered. Explain to students that they are in a position similar to that of the geologists who are studying the moon rocks.

5. Remind the students to choose from their rock collection six to be used in the next investigation.

Responses to Interpretation Questions

Refer to the Teachers' Key for the Mineral Identification Chart (see 1A-7) to determine whether students have made hypotheses based upon appropriate evidence.

1A-29

NAMING MINERALS IN ROCKS

OBJECTIVES

Processes

27. Order a set of ideas from least to most probable.

28. Construct an investigation and demonstrate the procedure to test an idea.

Concepts

1. A hypothesis is a "first idea" about an answer to a problem.

2. Usually a mineral specimen can be identified only after a wide range of qualitative and quantitative observations have been made.

3. A rock is composed of one or more minerals.

REFERENCE:

Zim. Rocks and Minerals

TEACHING SUGGESTIONS

Preparation

1. Students are to bring in 6 rocks that they wish to investigate. Have some extra rocks on hand for those students who forget to do so.

2. Set up the ultra-violet lamp and geiger counter stations as in previous activities. If you wish, stations may be set up for all the particular tests, for example, "mass measuring," "volume measuring," "streak tests," "hardness tests," etc. Because the investigation will last two or more days, this method may alleviate problems arising from the sharing of equipment with other teachers.

3. If possible, set up a conference schedule with each student to discuss progress. If necessary these can be held during class time while other students are working.

Cautions

Warn students about the proper handling of acid and the ultraviolet lamp.

Procedure

1. This activity is designed to provide each student an opportunity to practice science in an independent investigation.

2. Have each student place on his desk the six rocks he is to investigate. Review the term "hypothesis" and relate it to the introductory paragraph in the student manual.

3. Describe the manner by which students are to work, whether it will be in small group areas or at stations set up around the room. Explain that each student is to work individually on his own rock specimens, naming no more than four possible minerals for each rock based on the evidence he has gathered

Expected Results

Results will vary according to each student's motivation and interest. The main criterion for evaluation should be whether evidence supports hypotheses, not whether minerals have been named exactly. If individual conferences are held, a student can be asked to demonstrate one or more of the identification tests. Also you can discuss with the student the processes and concepts of the course.

Discussion

When all work on identification has been completed the time has come for a summarizing discussion for Phase One. Begin by asking students which tests they felt were most useful in identifying minerals in rocks. List these on the chalkboard. Ask whether each test was a qualitative or a quantitative observation. Review the meaning of these terms.

Then lead the discussion to more general matters. What is the nature of a concept? Here is one way to demonstrate a concept: Explain that you are going to point to several students in the class. As you point to some you will say "yes" and as you point to others you will say "no." The class is to discover what it is that the "yes" students have in common. For example, all "yes" students may have blue eyes and blond hair, or all may have glasses, etc. Identify the common characteristic as a simple concept, observable among the "yes" students.

To emphasize the difference between a science concept and a science process, refer the class to the list of objectives in the Appendix of the student manual. Ask how these objectives differ from the concepts the students have learned about rocks and minerals.

Have the students select the science processes they used in their independent investigations of rocks. List their selections on the chalkboard. Have the class decide which of these processes were of greatest value to them in their investigation of minerals in rocks.

FINAL ASSESSMENT TASK FOR PHASE ONE

PART I

Read the following story:

Donald and Stanley went on a "rock and mineral hunt" one day. They were investigating some rock specimens collected from an old quarry located nor far from their community. Donald compared one of his rock samples with one that Stanley had collected.

He decided that he would make the first observations of the two rocks by first looking at their appearance and then making measurements using a copper penny, a knife blade, a balance, and a graduated cylinder with some water in it.

He wrote his observations in the chart below.

DONALD'S DATA

Specimen	Color	Luster	Streak	Hardness	Mass
Rock A	gray	metallic	black	2	30 g
Rock B	black	metallic	black	2	30 g

Donald told Stanley that on the basis of his observations, he was sure the two rocks were the same. Stanley looked at Donald's chart. He decided to make some observations of his own, using the same testing materials that had been used by Donald. Stanley wrote his observations in the chart below.

STANLEY'S DATA

Specimen	Color	Luster	Streak	Hardness	Mass	Volume	Other Properties
Rock A	gray	metallic	black	3	30.5 g	4.1 ml	Cubic outcrops
Rock B	black	metallic	black	2	30.2 g	15.1 ml	Feels greasy

Compare the observations of Donald and Stanley. For each of the items below, choose the best one of the four endings. Place the letter of your choice in the blank provided. You may refer to the Mineral Identification Chart in your manual.

____ 1. On the basis of Donald's observations, the two rocks are:

a. the same color
b. different imluster
c. the same volume
d. similar in appearance

____ 2. Stanley's data chart indicates the two rocks have:

a. the same color
b. the same hardness
c. different volumes
d. different masses

____ 3. Stanley was probably more accurate than Donald in his observations of:

a. streak
b. color
c. mass
d. luster

____ 4. On the basis of Stanley's information, the two rocks differ most in:

a. volume
b. luster
c. mass
d. color

____ 5. Stanley had gathered enough data so that he was able later to add two more columns to his chart. These columns were "Density" and "Specific Gravity." The densities of the rocks would be:

a. Rock A = 121 g/ml;
Rock B = .5 g/ml

b. Rock A = 30.5 g/ml;
Rock B = 30.2 g/ml

c. Rock A = 7.4 g/ml;
Rock B = 2 g/ml

d. Rock A = 4.1 g/ml;
Rock B = 15.1 g/ml

____ 6. When the density of a rock is expressed as $\frac{\text{grams}}{\text{milliliter}}$, the numbers in the "Specific Gravity" column for each rock will be:

a. the same number
b. two times the density
c. ten times the density
d. one-half the density

_____7. On the basis of the data in the charts made by both of the boys, Rock A is composed mainly of:

a. graphite
b. hematite
c. calcite
d. galena

_____ 8. On the basis of the data in the charts made by both of the boys, Rock B is composed mainly of:

a. talc
b. graphite
c. halite
d. galena

_____ 9. The least valuable information for distinguishing between the minerals in the two rocks were:

a. streak and luster
b. color and hardness
c. mass and volume
d. other properties

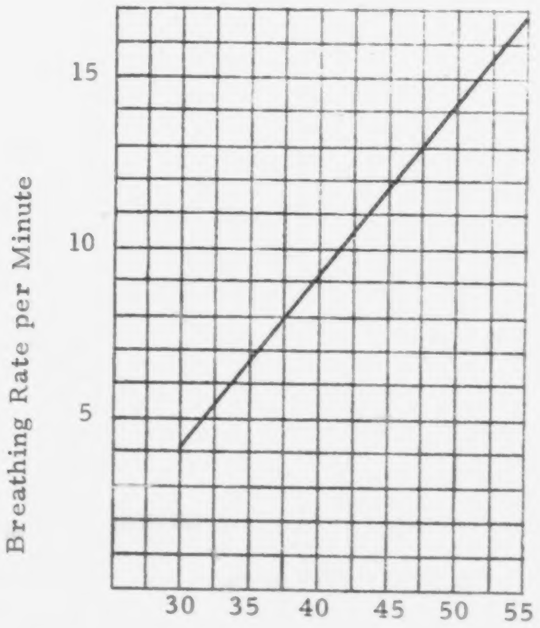
_____10. Of the following, the most valuable information for distinguishing between the minerals in the two rocks was:

a. streak and luster
b. color and hardness
c. mass and volume
d. fracture

PART II

Study the following graph. Answer the questions by placing the letter of the best response in the spaces to the left.

Breathing Rate of an Insect



Temperature, °F

____ 1. Of the following, which term does not refer to the "Temperature °F"?

a. dependent variable
b. independent variable
c. horizontal axis
d. ordered measurement

____ 2. Which one of the following statements best describes what the graph tells you?

a. The insect gets warmer as it breathes faster.
b. The insect gets colder as it breathes more slowly.
c. The insect breathes faster as the temperature drops.
d. The insect breathes faster as the temperature rises.

_____ 3. At a temperature of 40°F, the insect breathes at what rate?

a. about 10 times per minute
b. about 10 times per second
c. about 8.5 times per second
d. about 9 times per minute

_____ 4. At what temperature does the insect breathe about 12 times per minute?

a. less than 40°F
b. about 44°F
c. about 50°F
d. about 46°F

PART III

In a certain area, observations were made of the number of grasshoppers and the number of barn swallows. Count of each animal was made twice each month. The data appear in the chart below. Study the chart. Then answer the questions that follow it, placing the letter of the best answer in the space to the left of the question.

Date	Number of Grasshoppers	Number of Barn Swallows
April 15	0	0
May 1	24	0
May 15	30	0
June 1	30	19
June 15	28	22
July 1	22	24
July 15	20	22
August 1	17	24
August 15	13	24
Sept. 1	10	24
Sept. 15	11	24
Oct. 1	10	0
Oct. 15	10	0
Nov. 1	6	0
Nov. 15	0	0

_____ 1. Between which of the following dates did the grasshoppers suddenly become greater in number?

a.	May 1 and May 15	c.	Sept. 1 and Sept. 15
b.	April 15 and May 1	d.	July 15 and August 1

_____ 2. Between which of the following dates did the number of grasshoppers remain nearly the same?

a.	August 1 and Sept. 15	c.	May 15 and June 15
b.	April 15 and May 15	d.	July 15 and September 1

_____ 3. Between which of the following dates did the barn swallows suddenly become greater in number?

a.	May 15 and June 1	c.	June 15 and September 15
b.	June 1 and June 15	d.	July 1 and September 15

_____ 4. Between which of the following dates did the number of barn swallows remain nearly the same?

a.	April 15 and June 15	c.	September 15 and Oct. 1
b.	July 1 and September 15	d.	June 1 and July 1

_____ 5. Which of the following hypotheses is least supported by the data in the chart?

a. Grasshoppers become numerous in that area between April 15 and May 1.

b. Grasshoppers could be a source of food for barn swallows in that area.

c. Grasshoppers live longer than barn swallows.

d. Barn swallows live in the area between June 1 and September 15.

_____ 6. Which of the following hypotheses is best supported by the data?

a. Grasshoppers always appear in that area before the barn swallows.

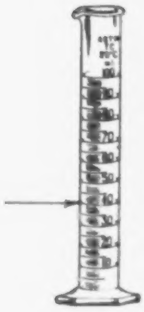
b. Barn swallows eat most of the grasshoppers in that area between June 15 and September 15.

c. As the number of barn swallows became greater in that area between June 1 and September 15, the number of grasshoppers became smaller.

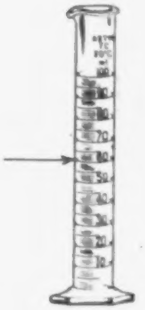
d. As the number of grasshoppers became smaller in that area, the number of barn swallows greatly increased.

PART IV

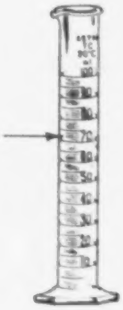
Read the volumes indicated on the diagrams of graduated cylinders below. Answer the questions that follow by choosing one of the diagrams and placing its letter in the space to the left of the question.



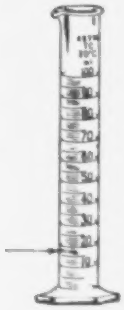
A



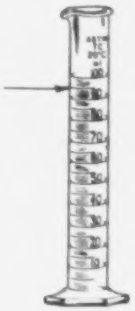
B



C



D



E

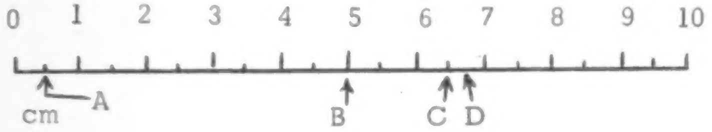
_____ 1. Which graduate cylinder contains the smallest volume?

_____ 2. Which graduate cylinder contains the greatest volume?

____ 3. A rectangular container having a length of 10 cm, a width of 3 cm, and a height of 2 cm was filled with water. Which of the graduate cylinders shows a reading with exactly the volume of water in the rectangular container?

PART V

Several points have been identified on the metric scale below. Choose the letter of the point that best answers the questions that follow.



____ 1. Which point shows a measurement of .5 cm?

____ 2. Which point shows a measurement that lies between 6.5 cm and 7.0 cm?

Answers to Final Assessment Task, Phase One

Part I

1. d
2. c
3. c
4. a
5. c
6. a
7. d
8. b
9. a
10. c

Part II

1. a
2. d
3. d
4. d

Part III

1. b
2. c
3. a
4. b
5. c
6. c

Part IV

1. D
2. E
3. B

Part V

1. A
2. D

MATERIALS AND EQUIPMENT

Option A

1A-1. Observation

Box #1
- shoe boxes, 4
- tapes, 1
- clay pieces, 4
- metal pieces, 4
- vials of water, 4
- rocks, 4

Box #2
- shoe boxes, 4
- cloth pieces, 5"x8", 4
- cloth bags, 12
- metal shot, 1 lb.
- sand, 2 lb.
- navy beans, 1 lb.
- corn meal, 2 lb.

Box #3
- shoe boxes, 4
- tapes, 1
- nails, 4
- sponge pieces, 4
- paper clips, 4
- marbles, 4

Box #4
- shoe boxes, 4
- tapes, 1
- rocks (hand size), 4
- wood dowels, 4

Box #5
- plaster of Paris, 5 lb.
- or
- Play-doh, 1 lb.

1A-2. Observing Planet G

beakers, 600 ml, 2
acetic acid, 5%, 400 ml
ice cubes, 5
halite cubes, 5

Secondary School Science Project. Time-Space-Matter, Teacher Folio for Investigation 3.

Baltimore County Board of Education. Film Loop I, Zooming in on Planet G.

Baltimore County Board of Education. Tape I, Unmanned Probe.

1A-3. A Closer View of Planet G

beaker, 1000 ml, 1
bicarbonate of soda, 1 tsp.
food coloring, 1 or 2 drops
moth-balls, 4
acetic acid, 5%, 100 ml.

Baltimore County Board of Education. Slides of Planet G.

1A-4. Surface Samples from Planet G

vials with caps - empty, 20
vials with caps - pebbles, 20
vials with caps - sand, 20
vials with caps - salt water, 20
vials with caps - tap water, 20
vials with caps - wood, 20

1A-5. Use of Instruments

granite (hand specimen), 1
synthetic granite, 1
hand lenses, 40

Beauchamp. Everyday Problems in Science (1963 ed.).

1A-6. Investigating Rocks

granite, pink, 20
marble, white, 20
gneiss, 20
basalt, 20
schist, mica, 20
sandstone, 20
bank pin, 40
hand lenses, 40
glass slides, 100
Elmer's Glue, 1 tube
vials with caps - empty, 20
vials with caps - water, 20
vials with caps - pebbles, 20
stereomicroscope, all available

Zim. Rocks and Minerals.

1A-7. A Closer Look at a Rock

granite, pink, 20
hand lenses, 40
paper towels, 200
crushed granite, 200 cc
bank pins, 40
vials with caps, 40
quartz, 5
feldspar, 5
hornblende, 5
biotite, 5
stereomicroscope, all available

1A-8. Describing the Hardness of Minerals

pennies, or copper electrodes, 20
nails, 20
glass slides, 20
gypsum, 40
apatite, 40
quartz crystal, 40
topaz, 40
steel files, 20
talc, 40
fluorite, 40
calcite, 20
milky quartz, 20
corundum, 20

Thurber and Kilburn. Exploring Earth Science.

1A-9. Describing the Appearance of Minerals

halite, 20
hematite, 20
magnetite, 20
muscovite, 20
obsidian, 20
quartz crystal, 20
calcite, 20
graphite, 40
pyrite, 40
willemite, 40
gypsum, 40
streak plates, 100
talc, 20
fluorite, 20
calcite, 20
milky quartz, 20
corundum, 20
asbestos, 20
biotite, 20
feldspar, 20
galena, 20
garnet, 20

Thurber and Kilburn. *Exploring Earth Science.*

Zim. *Rocks and Minerals*.

1A-10. Collecting Rocks

hand lenses, 40
bank pins, 40
paper towels, 1 pkg.

Baltimore County Board of Education. Film Loop I, *Zooming in on Planet G.*

Baltimore County Board of Education. Tape I, *Unmanned Probe.*

Baltimore County Board of Education. *Slides of Planet G.*

Zim. *Rocks and Minerals.*

1A-11. Discovering Another Characteristic

Blanc et al. *Modern Science 3*.

Herron and Palmer. *Matter, Life, and Energy*.

Namowitz and Stone. *Earth Science, The World We Live In* (1969 ed.).

Zim. *Rocks and Minerals.*

1A-12. A Principle of Measurement

blank paper, 20 pc.

1A-13. Measuring Length

orange standard unit (10 cm), 25
blue standard unit (100 cm), 20
black sheet of paper, 20
commercial meter sticks, 20
ring stands, 20
string, 1 to 2 m, 20
sheet of line segments, 20
beakers, 400 ml, 20
white standard unit (1cm), 20

1A-14. Size of Surfaces

white area units (1.5 cm x 1.5 cm), 600
rulers (metric), 20

1A-15. Measuring the Space that Matter Occupies

aluminum cubes, 600
assorted boxes, 120
large rectangular solid, 1

1A-16. A Volume-Measuring Device

clear plastic tubes, 20
glass marbles, 80
transparent tape, 20 pc.
rulers, metric, 20
rocks (3 different sizes), 1 set
beakers, 1000 ml, 1
food coloring, 1
graduated cylinders, 100 ml, 20
aluminum cubes from density kits, 20
aluminum slabs from density kits, 20
graduated tapes, 20 pc.

Swartz. Measure and Find Out, Book Two.

1A-17. Measuring Mass

meter sticks, 20
spool of thread, 1
lever knife-edge clamps, 20
lever knife-edge supports, 20
galena, 20
calcite, 20
metal washers, 300
lengths of wire (15 cm), 80
rubber stoppers, 1 hole, #6, 100

1A-18. A Mass Measuring Device

triple beam balance, 20
filter paper, 20 sheets
marble, 20
granite, 20
density kits, 20
beakers, 400 ml, 20
one gram masses, 10
film, 16 mm, "The Triple Beam Balance", 1

Beauchamp. *Everyday Problems in Science.*

Herron et al. *Matter, Life and Energy.*

Swartz. *Measure and Find Out, Book Two.*

1A-19. Putting Measuring Skills to Work

graduated cylinder, 100 ml, 20
triple beam balance, 20
rulers, metric, 20
specific gravity cylinder, copper, 20
specific gravity cylinder, brass, 20
specific gravity cylinder, aluminum, 20
aluminum cubes from density kits, 20
aluminum slabs from density kits, 20
paper towels, 1 pkg.

1A-20. Describing Minerals

biotite, 10
magnetite, 10
calcite, rhombic, 10
galena, 10
obsidian, 10
willemite, 10
quartz, crystal, 10
triple beam balance, 10
metric scales, 10
copper pennies, 10
iron nails, 10
glass slides, 10
graduated cylinders, 25 ml, 10
streak plates, 10

Namowitz and Stone. *Earth Science, The World We Live In* (late ed.).

Ramsey, *Modern Earth Science* (revised ed. 1969).

Thurber and Kilburn. *Exploring Earth Science.*

Zim. *Rocks and Minerals.*

1A-21. Other Tests for Minerals

radioactive mineral, 1
geiger counter or nuclear minilab, 1
magnetite, 1
bar magnet, 1
wernerite, 1
strontium chloride, 1 (optional)
copper sulfate wire, #20 or #22, 10 grams
iron filings, 10 grams
sodium chloride, 10 grams
magnetic compass, 1
bunsen burner, 1
overhead projector, 1 (optional)
willemite, 1

Zim. *Rocks and Minerals.*

1A-22. *The Relationship Between Mass and Volume, Part A*

graduated cylinders, 100 ml, 10
beakers, 250 ml, 10
triple beam balance, 10

Thurber and Kilburn. *Exploring Earth Science.*

Swartz. *Measure and Find Out, Book Two.*

1A-23. *The Relationship Between Mass and Volume, Part B*

triple beam balance, 10
alcohol, methyl, 100 ml, 10
tap water, 100 ml, 10
magnesium sulfate sol., 100 ml, 10
beakers, 150 ml, 30
graduated cylinders, 100 ml, 10

Blanc et al. *Modern Science.*

Brandwein et al. *Matter, Its Forms and Changes.*

Swartz, *Measure and Find Out, Book Two.*

Thurber and Kilburn. *Exploring Physical Science.*

1A-24. *Determining the Density of Solids*

aluminum cubes, 10
aluminum slabs, 10
steel balls, 10
quartz, milky, 10
pumice, 10
graduated cylinders, 100 ml, 10
triple beam balance, 10
beakers of water, 10
metric scales, 10
dissecting needles, 10

Blanc et al. *Modern Science.*

Brandwein et al. *Matter, Its Forms and Changes.*

Swartz. *Measure and Find Out, Book Two.*

Thurber and Kilburn. *Exploring Physical Science.*

1A-25. *The Density of Air*

vacuum pump and hose, 1
weight of air cylinder, 1
triple beam balance, 1

Educational Services, Inc. *Introductory Physical Science.*

Thurber and Kilburn. *Exploring Earth Science.*

1A-26. Specific Gravity

biotite or muscovite, 10
quartz, milky, 10
feldspar, 10
garnet, 10
magnetite, 10
calcite, 10
spring scales (500 g. if
available), 10
triple beam balance, 10
beakers, 250 ml. grad., 10

1A-27. Distinguishing Similar Rocks

streak plates, 10
spring scales, 10
triple beam balance
(optional), 10
ultra-violet lamp, 1
geiger counter, 1
beaker, 250 ml, 10
magnetic compasses, 10
marble, 10
quartzite, 10
calcite, rhombic, 10
hydrochloric acid, dilute, 10
glass slides, 10
nails, 10
pennies, 10
hand lenses, 10

1A-28. Naming Minerals

quartz crystals, 10
galena, 10
willemite, 10
sulfur, 10
halite, 10
biotite, 10
hematite, 10
magnetite, 10
garnet, 10
feldspar, 10
calcite, crystal, 10
talc, 10
nails, 10
pennies, 10
slides, glass, 10
fluorescent lamp, 1
spring scales or
triple beam balance, 10
geiger counter, 1
beakers, 250 ml, 10
magnetic compasses, 10
streak plates, 10
hydrochloric acid, dilute, 10

Baltimore County Board of Education. Student Mineral Identification Chart.

1A-29. Naming Minerals in Rocks

nails, 10
pennies, 10
slides, glass, 10
ultra-violet lamp, 1
spring scales or
triple beam balance, 10
geiger counter, 1
beakers, 250 ml, 10
magnetic compasses, 10
streak plates, 10
hydrochloric acid, dilute, 10

Zim. Rocks and Minerals.

IB-1

THE SEARCH

OBJECTIVES

Processes

1. Identify the appropriate sense needed to make an observation.

2. Distinguish between an observation and a non-observation.

Concepts

1. Because observation is the basis on which science rests it is important to make observations accurately.

2. Things that we observe are not always exactly as they appear.

REFERENCE

Goldstein. How to Do an Experiment. pp. 28-32

TEACHING SUGGESTIONS

Preparation

You may want to prepare an overlay of the optical illusions on Page 2 of the student manual. This can be used for the class discussion.

Procedure

1. Have the students complete Item 1 under Procedure.

2. Place an apple or another object that has both odor and taste on the demonstration table. Have the students fill in Items 2 and 3.

3. Follow this with a class discussion. A ruler can be used to check the illusions. Start discussion of Item 2 by having students place observations on the board until most of the possible observations are listed.

For Item 3, have a student read the observations he made and then give other students a chance to guess the identity of the object from the observations. Repeat with other students as time permits. In summarizing point out the importance of using as many senses as possible when making observations. Discuss observations and non-observations. It is not necessary to use the word inference at this time, but if students use the word you can discuss it briefly. There is no need for a detailed discussion about the difference between an observation and an inference.

Expected Results

1. Although many students may be familiar with optical illusions you can point out that what is observed with the sense of sight is not entirely accurate. Only after using a tool (ruler) can an accurate observation be made.

2. Students could list: color, size, shape, odor, texture from the sense of touch, possibly sound as it hits the desk, and even taste.

3. If there is not a sufficient variety of objects in the room supply some for the occasion. Students should describe color, shape, size, and the like.

Related Activity

Have students read Goldstein, How to Do an Experiment, pp. 28-32 to find out why the senses cannot be depended upon for accurate observations.

1B-2

INSECTS INVADE FARM

OBJECTIVES

Processes

1. Identify the appropriate sense needed to make an observation.

3. Name qualitative characteristics of an insect, using one or more of the senses.

Concept

. Scientists use observations to collect data that may help solve practical problems.

REFERENCE

Zim. Insects. p. 22

TEACHING SUGGESTIONS

Preparation

Have one preserved cricket available for every two students. To reduce the odor from the preservative place the crickets in water overnight. Provide a petri dish to contain the cricket while the observations are being made.

Cautions

Warn against the use of the sense of taste. These crickets will be used again.

Procedure

1. At the beginning of the period have the students read the introductory paragraph. Discuss the handling of the crickets, pointing out that they will be used again. Allow students a reasonable time to make their observations.

2. Have one student at a time write an observation on the board. Then determine the approximate number of students that made each observation.

3. Allow students time to complete the Interpretation items.

4. Discuss the interpretation items. . Conclude the discussion by asking the students, "Which of your observations would be most useful to scientists in an agricultural laboratory for identifying the insect that was responsible for the crop damage"?

Responses to Interpretation Questions

1. The list of possible observations is numerous and may contain some items that are not observations.

2. Most observations will be made by the sense of sight, but the senses of touch and smell are also applicable.

3. Student responses will vary and may include:
   a. Some students use their sense more effectively.
   b. Some students look for more detail.
   c. Some students observe better than others.

4. According to Zim, *Insects*, field crickets damage crops. Therefore, an acceptable response would be that the crickets could be responsible for the crop damage.

Assessment Task

For each quality on the left identify from the list on the right the sense used to observe it. (For the teacher answers are supplied in parentheses.)

Quality	Sense
(e) color of a ball	a. hearing
(a) loudness of a voice	b. taste
(d) roughness of a stone	c. smell
(c) odor of a rose	d. touch
(b) saltiness of a pretzel	e. sight

OBSERVING INSECTS

OBJECTIVES

Processes

2. Distinguish between an observation and a non-observation.

3. Name the qualitative characteristics of objects, using one or more of the senses.

Concept

What a viewer observes may depend on his position in respect to the object viewed.

TEACHING SUGGESTIONS

Preparation

Obtain small plastic containers or baby food jars to contain the live insects. Have available one large grasshopper with one leg, one antenna, and one wing removed. Remind students to bring in one or more live insects for this investigation.

Caution

Discourage students from bringing in insects that bite or sting. Be on the alert for any such insects that may arrive.

Procedure

1. If the insects are in large containers, have them transferred to smaller containers. You may wish to avoid confusion by having students keep the insects in containers, but some observations may be lost thereby.

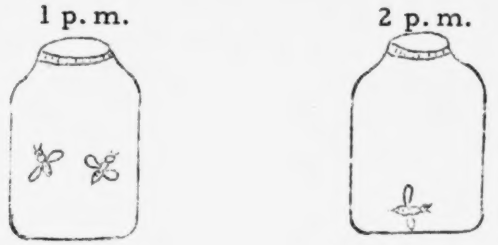
2. Place at the front of the classroom the grasshopper from which parts have been removed. Tell students to make their observations but to delay work on the interpretation items.

3. After the students have observed the grasshopper, compare the observations made by students sitting in the back of the room with observations made by students sitting near the

front of the room. Then have the interpretation items completed.

4. Use the objectives as a guide for the post-laboratory discussion. Have students compare their observations of living insects. Use Interpretation Item 2 as a basis for discussing the difference between an observation and a non-observation or inference.

5. On the board, sketch the diagram below. Ask the students to make as many observations about the diagram as possible. The significant observation is that there are two insects in one jar and one insect in the other. Some students, however, may comment that one of the insects must have eaten the other. This is an inference. Many other inferences are possible.



Responses to Interpretation Questions

1. Many observations may be similar to those made in the previous investigation. However, students may also observe movements and possibly sounds.

2. Students sitting in the back of the room may make some responses on the basis of inference; for example, they may record six legs, two antennae, and four wings, but some students in the front of the room will probably correctly observe five legs, one antenna, and three wings.

3. Science is based on verifiable observations. So long as a scientist restricts his report of observations to his sense impressions, any other scientist with properly functioning sense organs can verify them.

4. Observation is the determination of the characteristics of objects or events by use of the senses.

Assessment Task

Use the assessment task described in 1A-3, "A Closer View of Planet G."

WHAT IS AN INSECT?

OBJECTIVES

Process

3. Name the qualitative characteristics of objects, using one or more of the senses.

Concept

Insects have the following characteristics that distinguish them from other animals: six legs, three body regions, one pair of antennae, and, usually, two pairs of wings.

REFERENCE

Thurber and Kilburn. Exploring Life Science. pp. 60-63

TEACHING SUGGESTIONS

Preparation

Preserved grasshoppers (one for every two students) should be removed from the preservative the day before this activity and left in water overnight. This will dilute the preservative and prevent irritation to the student's skin.

Procedure

1. Have the students read the introductory paragraph and briefly discuss the question. Accept any ideas presented and make a minimum of comment. Before distributing the grasshoppers, request the students not to damage the insects, since they will be used again. For Item 5, have students point out the part of the grasshopper to team member or to you.

2. Grasshoppers have been chosen for study because they clearly exhibit the basic characteristics of an insect. As these basic characteristics are discussed, refer to the observations made in 1B-3 for comparisons. Insects vary greatly. Many insects have two pairs of wings; some have one pair of wings; some have no wings. Another major adaptation in insects is the

wide variety of mouth parts adapted to varied feeding habits. Adaptability in part can explain the vast numbers as well as the wide range of insects.

Responses to Interpretation Question

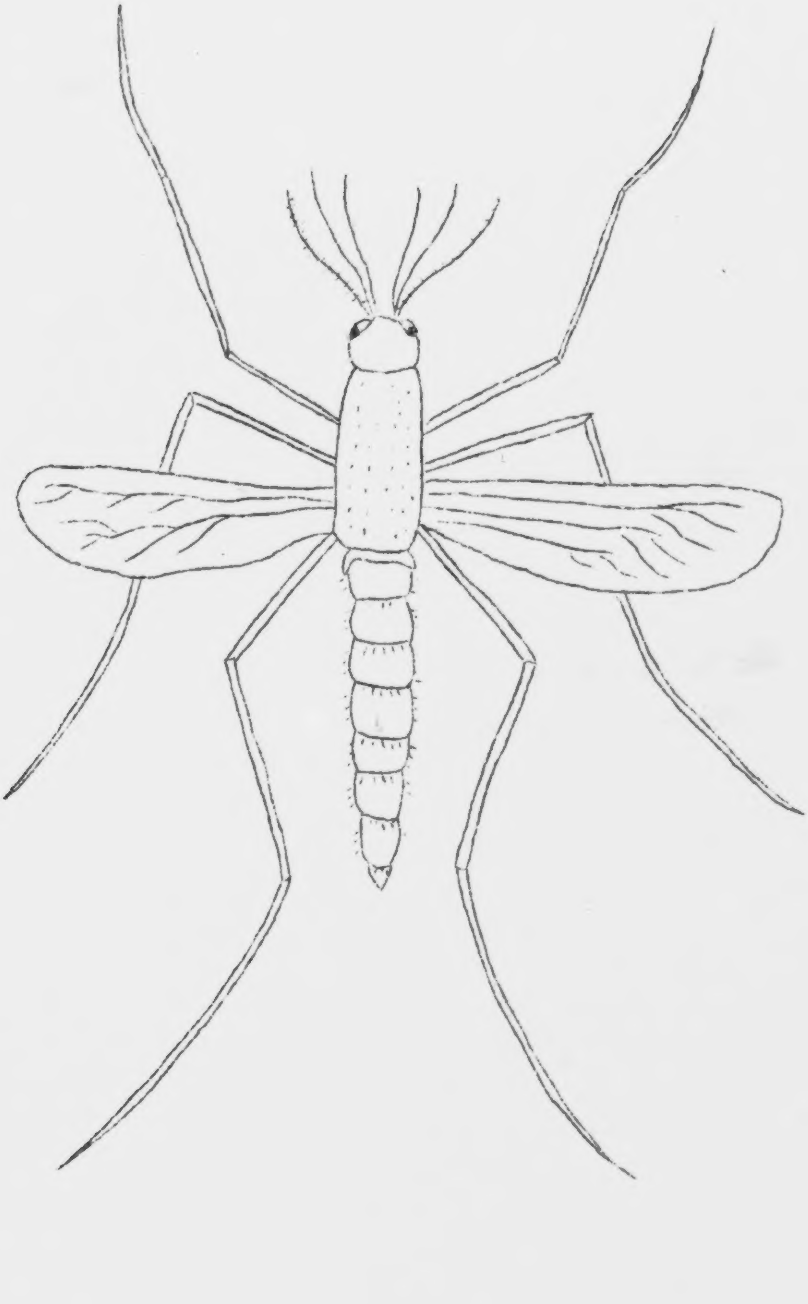
Three body regions (head, thorax, and abdomen), six legs, one pair of antennae, and one or two pairs of wings. The last characteristic is lacking in some insects.

Assessment Task

Prepare a Thermofax ditto of the illustration of the mosquito. Have students identify and name: head, thorax, abdomen, wing, antenna, eye, and leg.

Related Activity

Have the students read Zim, Insects, pp. 6-8 to gain a general knowledge of the number and range of insects. This reading will review the characteristic parts of an insect and also point out insect-like animals.



1B-5

CHARACTERISTICS OF INSECTS

OBJECTIVES

Process

3. Name the qualitative characteristics of objects, using one or more of the senses.

Concepts

1. Grasshoppers have specialized body parts such as spiracles, wings, legs, mouth parts, eyes, antennae, and palps.

2. Most insects pass through a number of stages while developing into an adult.

3. Many insects have a specialized organ that is highly developed for one purpose.

REFERENCES

Klotz. 1001 Questions about Insects

Thurber and Kilburn. Exploring Life Science. pp. 60-65

TEACHING SUGGESTIONS

Procedure

1. This activity is a directed reading lesson. For motivation, discuss some interesting facts about insects from 1001 Questions about Insects. Some facts that can be used are Examples 11, 14, 15, and 16.

2. The students have read Pages 60-63 in Exploring Life Science as part of 1B-4. Have them reread these pages for deeper understanding and continue reading through Page 65.

3. Discuss the comprehension questions after the students have completed the work for 1B-5 in the student manual.

Responses to Interpretation Questions

1. b
2. to allow for growth
3. 1, a; 2, f; 3, a; 4, d; 5, b; 6, b
4. b
5. b
6. c

7.

Insect	Name of Specilized Organ	Functions
1. Beetle	front wings	protects
2. Praying mantis	front legs	holds other insects while it eats them
3. Moth	long tongue	obtains nectar from deep flowers
4. Fly	last segment of abdomen	drills holes in trees in which to deposit eggs

8. Some students may say that all of the animals are not insects because the caterpillar has more than six legs. Other students may say that all of the animals are insects because the caterpillar is an insect in the larval stage. The correct answer is that all the animals pictured are insects. Caterpillars have six legs but, in addition, have structures that function as legs but that differ structurally from the "true" legs.

Assessment Task

Place the following objects in small beakers: ammonia, water, catsup, and a piece of obsidian. Have the students name the qualitative characteristics of each object and the senses used to detect each characteristic.

Acceptable Responses

1. ammonia: liquid, clear, colorless, irritating (sight and smell)

2. water: liquid, clear, colorless, odorless (sight and smell)

3. catsup: liquid, red, spicy odor (sight and smell)

4. obsidian: black, shiny, odorless, glossy, hard, smooth (sight, smell, touch)

1B-6

INSECT COLLECTING

OBJECTIVES

Process

4. Demonstrate the ability to locate, collect, and preserve insects.

Concepts

1. Insects are found in a wide variety of environmental conditions.
2. There are specific techniques for collecting, pinning, and storing insects.
3. The variety and numbers of insects are best appreciated by making collections.

REFERENCES

Siverly. Rearing Insects in School. pp. 8-9

Thurber and Kilburn. Exploring Life Science. pp. 53-54

DeWaard. What Insect Is That?

TEACHING SUGGESTIONS

Cautions

The procedure as given in the student manual involves no special hazards. For students who go beyond this some cautions are necessary.

1. Do not give students any chemicals to use in their collecting containers. If they use chemicals, they must obtain their own.
2. Carbon tetrachloride is toxic and should not be used.
3. Ethyl acetate is an ingredient of model airplane glue and should not be used.
4. Rubbing alcohol may be used, but is very slow in killing insects and may discolor them.
5. Petroleum ether is fairly effective and relatively safe, if kept away from flames.
6. Warn students (especially those with known allergies) about bee stings.

Procedure

1. Natural curiosity and the propensity for collecting should provide motivation for this activity. Ask all students in the class to collect insects. A few students may be interested enough to construct more elaborate equipment than suggested in the student manual. These students can be given information on purchasing or making their own equipment. Refer students to references such as What Insect Is That?
2. Tell the students that they will use their insect collections at a later date to develop a classification system. Therefore, it is important that they collect as many different insects as possible and preserve them carefully.
3. Discuss and demonstrate the specific techniques for collecting, pinning, and storing insects. It is important to stress the cautions before the students begin their collection. If desirable, take the class outdoors to help them start their collection.
4. Although the Thurber and Kilburn reference recommends carbon tetrachloride to kill insects, tell the students they are not to use it. To learn collecting and storing techniques you may want to have the students read Pages 50-54 instead of Pages 53-54 only.
5. In the discussion of Interpretation Items 3 and 4, point out that an insect collection can be valuable for study or reference.

Responses to Interpretation Questions

1. The delicate wings of butterflies and moths are easily damaged by other insects. The scales on moths and butterflies can discolor other insects.
2. Chemicals that kill insects are also harmful to humans.
3. When collecting insects, you can learn about their habits, habitats, foods, and movements.
4. An insect collection enables you to observe the structure of insects closely and at leisure. Direct comparisons can be made between kinds of insects. A display of collected insects illustrates the diversity of insects.

1B-7

PILL BUGS IN A PILL BOX

OBJECTIVES

Process

3. Name the qualitative characteristics of objects, using one or more of the senses.

Concepts

1. In a laboratory it is possible to test ideas that arise from field observations.
2. Although they resemble insects in some ways pill bugs are not insects because they lack the characteristics by which insects are defined.
3. Pill bugs move away from a light source.

REFERENCES

Thurber and Kilburn. Exploring Life Science. pp. 72-73

Morholt, et al. A Sourcebook for the Biological Sciences. pp. 599-600

TEACHING SUGGESTIONS

Preparation

Have students collect pill bugs a day or two before they are needed. They can be found under stones, boards, and logs and in other dark, moist, undisturbed places. Pill bugs can be maintained in the classroom for several weeks in a terrarium. Place about one inch of soil, some decaying work, and fruit in the terrarium and keep it damp. Collecting and culturing pill bugs is described in the reference by Morholt, et al.

Caution

Be sure that the paper towel is slightly moist. Too much water will make the pill bugs inactive.

Procedure

1. Distribute the materials and have the students complete the work outlined in the student manual.
2. Reproduce the student chart on the board with enough spaces so each group can fill in its data. When all groups have recorded the data, have the totals and averages calculated.
3. Through class discussion of the interpretation items develop the concepts for this activity.

Expected Results

Pill bugs move to the dark area of the box.

Responses to the Interpretation Questions

1. Pill bugs prefer a dark environment .
2. Because pill bugs prefer dark, moist areas with decaying organic matter for food, the area under a rock provides an ideal environment for them.
3. Pill bugs are not insects. A pill bug has more than six legs, and does not have three body segments.

Assessment Task

How could you determine the preference of an earthworm to a moist or dry paper towel?

Acceptable Response

Place several earthworms in a container which has moist towels at one end and dry paper towels at the other end. Observe the directions of the movements over a period of time.

IB-8

A CLOSER LOOK AT INSECTS

OBJECTIVES

Process

5. Demonstrate the use of a hand lens.

Concepts

1. An object viewed under a hand lens appears larger than its actual size.

2. An estimate of the magnification of a hand lens can be made by comparing the actual size of an object with the size it appears to be under the hand lens.

3. An object viewed under a hand lens shows more detail than it does when viewed with the naked eye.

REFERENCE

Thurber and Kilburn. Exploring Life Science. pp. 60-61

TEACHING SUGGESTIONS

Preparation

Ask the students to bring in small insects such as ants and aphids. If necessary, fruit flies can be ordered from Arbutus Junior High School by calling 242-2900. Allow one week for delivery.

Procedure

1. Demonstrate the proper use of a hand lens.

2. Tell the students to include as much detail as possible in their sketches.

3. Answers to Item 3 will vary. Most hand lenses available in the schools magnify 2, 6, or 8 times.

4. This investigation requires a minimum of discussion. Move on as rapidly as possible to 1B-9.

Responses to Interpretation Questions

1. A hand lens makes objects appear larger and details can be observed more easily.

2. Microscopes, telescopes, and binoculars are three instruments that have lenses.

Related Activity

Have the students read about the invention and use of magnifying lenses. Two references that can be used are:

Keen. How and Why Wonder Book of the Microscope. pp. 4-18
Ware. Life under the Microscope. pp. 2-4

THE PARTS OF A MICROSCOPE

OBJECTIVES

Process

6. Identify and describe the functions of the main parts of a microscope.

Concepts

1. Two lenses used in combination give greater magnification than either lens used alone.
2. Each part of a microscope has a specific function.

REFERENCES

Brandwein et al. Life, Its Forms and Changes. pp. 525-527

Keen. How and Why Wonder Book of the Microscope. pp. 12-14

TEACHING SUGGESTIONS

Procedure

1. Demonstrate a technique for using two hand lenses in combination.
2. Place 5 or 6 microscopes at various positions in the room so that the students can complete Item 5. Caution students not to handle the microscopes yet. Care and handling of the instrument are learned in 1B-10.
3. Some students may have difficulty computing the magnifications of the microscope. The magnification of the Zoom Scopes ranges from 25 to 100. The magnification of ordinary student microscopes ranges from 100 to 430. These ideas can be developed with the entire class during the discussion of the activity.

Responses to Interpretation Questions

1. Two hand lenses used in combination provide greater magnification than one hand lens used alone.

2. The principal advantage of using a microscope instead of two hand lenses is convenience. This can be broken down into specifics, such as: the freeing of the hands from holding the two lenses, the ease of focusing because the lenses are held a fixed distance apart by the tube, etc.

Assessment Task

Four microscopes are set up in a laboratory:

Microscope I has a 5x ocular and a 10x objective.
Microscope II has a 10x ocular and a 20x objective.
Microscope III has a 5x ocular and a 40x objective.
Microscope IV has a 4x ocular and a 40x objective.

If the eye of an ant is examined using each of the microscopes:

a. In which two microscopes would the ant's eye appear to be the same size?

b. In which microscope would the ant's eye appear the smallest?

c. In which microscope would you expect the largest field of view?

Acceptable Responses

a. II, III
b. I
c. I

LEARNING ABOUT THE MICROSCOPE

OBJECTIVES

Process

7. Demonstrate the proper use, care, and handling of the microscope.

Concept

To use any instrument effectively, it is necessary to employ proper techniques.

REFERENCE

Silver Burdett Company. Using the Microscope - Part I. (filmstrip and record)

TEACHING SUGGESTIONS

Preparation

Preview the filmstrip and record.

Procedure

1. Have students complete Item 1 in the student manual. For this show Frames 8, 10, 12, and 23 from the filmstrip without playing the record. These frames highlight four techniques for using the microscope. The student is asked to answer questions about the techniques from his observation of the frames before hearing an explanation. The four frames include:

Frame 8:	Carrying the microscope
Frame 10:	Adjusting the mirror
Frame 12:	Adjusting the diaphragm
Frame 23:	Seating the high power objective while viewing from the side.

2. Now, show the entire filmstrip and play the record, which is approximately 20 minutes in length.

3. Have the students complete Item 2 after viewing the filmstrip.

4. It may be necessary to show some frames of the filmstrip again if the students are unable to complete Item 2 successfully.

Expected Results

1. Frame 1 (Frame 8 of the filmstrip): Carry the microscope with both hands, one on the arm and the other under the base.

   Frame 2 (Frame 10 of the filmstrip): The mirror reflects light into the lenses.

   Frame 3 (Frame 12 of the filmstrip): The diaphragm controls the amount of light.

   Frame 4 (Frame 23 of the filmstrip): When seating the high power objective, look from the side; otherwise it is possible to break the slide and scratch the lens.

2. a. A microscope lens may be cleaned with lens paper.

   b. Move the slide in the same direction as the organism is moving.

   c. The lens may be dirty.

   d. Change back to low power.

   e. 2
   1
   3

   f. 5
   2
   4
   3
   6
   1

USING A MICROSCOPE

OBJECTIVES

Process

7. Demonstrate the proper use, care, and handling of a microscope.

Concepts

1. Objects viewed under the microscope appear inverted (upside down) and reversed.
2. As a microscope slide is moved from right to left, the image moves from left to right.
3. As a microscope slide is moved away from the observer, the image moves toward the observer.
4. The field of view under high power is smaller than under low power.
5. The illumination (light) under high power is less than under low power.

TEACHING SUGGESTIONS

Preparation

1. Before beginning this activity, have several students cut out from the newspaper small sections (about 5 mm square) containing the letter "e." The small print used for stock listings and sports statistics is the best size. It is also helpful if areas having no print on the reverse side are selected. Supply at least two pieces of newsprint for each student group.
2. Try to provide enough microscopes so that the students can work in pairs.

Procedure

1. Have several students demonstrate the proper techniques for using a microscope. Ask them to identify the parts and describe their functions.

2. Demonstrate the procedure for preparing a wet mount. Describe how to handle and clean the cover slip and microscope slide.

3. Remind the students of the cautions listed in their manual. It may be helpful to demonstrate the use of the high power objective as described in the student manual.

4. Students may have difficulty locating the "e" under the microscope. When magnified 100 times, an "e" in the smallest newsprint type takes up the entire field of view. When several students become proficient at locating the "e", ask them to help other students.

Expected Results

In Item 3, students should obtain the following results:

a. e
b. ə
c. toward the observer
d. to the right
e. clockwise
f. Under high power, the field of view is smaller and there is less light.

Responses to Interpretation Items

1. ɥ S ɟ

2. d

3. counterclockwise

Assessment Task

1. Using the same materials as previously listed, have students prepare a different wet mount and observe it through the microscope. The new object to be observed could be the

wing of a bee, the leg of a fly, the antenna of a butterfly, etc. Circulate around the room and observe the techniques of the individual students.

2. Order the following steps for focusing under low power:

   a. Turn the fine adjustment.
   b. Place the slide on the stage.
   c. Rotate the low power objective into place.
   d. Adjust the mirror for light.
   e. Looking from the side, lower the tube until it almost touches the slide.
   f. Turn the coarse adjustment knob toward you.
   g. Adjust diaphragm for clarity.

3. Place several letters on the chalkboard. Have the student make a sketch of the image of each letter as it would appear under a microscope.

Acceptable Responses

2. c, d, b, d, e, d, f, a, g

3. Each letter should be inverted and reversed.

STEREOSCOPIC MICROSCOPE

OBJECTIVES

Processes

8. Identify and describe the functions of the main parts of a stereoscopic microscope.

9. Demonstrate the proper use, care, and handling of a stereoscopic microscope.

Concepts

1. A stereoscopic microscope is really two microscopes; it has two oculars (eyepieces) and two objectives.

2. A stereoscopic microscope gives a three-dimensional image of the object viewed.

3. In this microscope, the image is not reversed or inverted as it is in the ordinary microscope.

TEACHING SUGGESTIONS

Preparation

1. Renew the supply of newsprint strips if necessary (see 1B-11).

2. Transfer a dozen or more fruit flies to an empty container such as a half-pint milk bottle. Kill the flies by placing a cotton stopper containing petroleum ether in the mouth of a bottle. In approximately five minutes the flies should be dead.

Procedure

1. Demonstrate the proper techniques for using the stereoscopic microscope.

2. Have a student demonstrate how to prepare a wet mount. This technique is described in 1B-11.

3. Distribute approximately two fruit flies to each group of students.

Expected Results

2.

Eyepiece	Objective Lens	Magnification
10X	1.5	15

4. a. The image is similar to the actual letter but larger.

b. The image seen through an ordinary microscope is inverted and reversed, but the image seen through a stereoscopic microscope is erect and not reversed.

c. The image moves from right to left.

5. A male fruit fly has five stripes on the abdomen. A female fruit fly has seven stripes on the abdomen.

Responses to Interpretation Questions

1\.

stereoscopic microscope	ordinary microscope
d	ɟ

2. An ordinary microscope provides higher magnification than a stereoscopic microscope.

3. a. stereoscopic microscope

b. stereoscopic microscope

c. ordinary microscope

d. stereoscopic microscope

e. ordinary microscope

MEASURING LENGTH

OBJECTIVES

Process

10. Demonstrate a procedure for measuring length.

Concepts

1. The meter is the standard unit of length in the metric system.

2. The units of the metric system are related by powers of 10.

REFERENCES

Miller. Understanding the Metric System.

Intermediate Science Curriculum Study (ISCS). Probing the Physical World, Excursion 1.

TEACHING SUGGESTIONS

Procedure

1. Begin with a class discussion of the Olympics. List on the chalkboard some typical events and the metric units used in each event; for example:

   100 Meter Dash
   400 Meter Run
   110 Meter Hurdles
   3, 000 Meter Steeplechase
   20, 000 Meter Walk
   1, 600 Meter Relay
   50 Kilometer Cross-Country Skiing
   40 Kilometer Relay

   Ask the class to estimate the distances in each event. Do not prolong this. The aim is not to achieve successful estimates; it is merely to introduce the metric system of measurement in the student manual as a transition from the study of the stereoscopic microscope to the study of measurement.

Expected Results

1.

a.	decimeter	deci-	one tenth
b.	centimeter	centi-	one hundredth
c.	millimeter	milli-	one thousandth

2. 10

3. 10

4. 100

5. 100

6. 100; centimeter; decimeter

7. 1000

8. A to B = 18 mm

A to C = 8.6 cm

B to E = 9.4 cm

D to C = 144 mm

D to C = 14.4 cm

Responses to Interpretation Questions

1. The distance from A to K is one decimeter.

From A to B, B to C, and so on, each unit is a centimeter.

Each of the smallest division marks represents one millimeter.

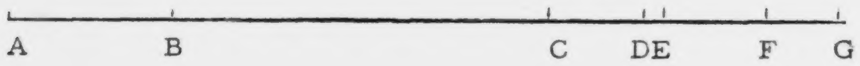
2. The distance from A to F is one-half of a decimeter.

3.

Unit	Abbreviation	Part of Meter
decimeter	dm	$\frac{1}{10} = 0.1$
centimeter	cm	$\frac{1}{100} = 0.01$
millimeter	mm	$\frac{1}{1000} = 0.001$

4. The celebrated hopper earned ten cents.

Assessment Task



Study the line above. You may use a ruler to determine length. Then choose the best answer from each set below. Indicate your choice by circling its letter.

1. The distance from A to C is:

a. 8 cm b. 75 mm c. 8 dm d. 80 cm

2. The distance from B to F is:

a. 94 mm b. 88 mm c. 88 cm d. 18 mm

3. The distance from E to F is:

a. 2 cm b. 4 mm c. 3 mm d. 2 mm

4. The distance from A to G is:

a. 123 mm b. 12 cm c. 1.3 dm d. .1M

Acceptable Responses

1. a

2. b

3. d

4. a

LENGTH OF GRASSHOPPER LEGS

OBJECTIVES

Process

10. Demonstrate a procedure for measuring length.

Concepts

1. All measuring procedures involve errors.
2. The front legs of a grasshopper are the shortest; the hindlegs are the longest.

TEACHING SUGGESTIONS

Preparation

Soak the grasshoppers in water overnight.

Caution

1. Remind students not to touch their eyes with their fingers after handling the grasshoppers.
2. Remind students to handle the grasshoppers carefully because they will be used again.

Procedure

1. Have the students identify the hindlegs, middle legs, and front legs of the grasshoppers. Also, ask them to locate the upper, middle, and lower segments of each leg.
2. If some students have difficulty measuring the segments, it may be necessary to demonstrate this technique.
3. Collect the grasshoppers when the activity has been completed.
4. Some student may question the relevancy of this activity. Therefore, it is important to stress the process objective.

Expected Results

Measurements of the segments of the legs vary because of variation in the size of the grasshoppers.

Responses to Interpretation Questions

1. The upper and middle segments of each leg of a grasshopper are equal in length.
2. a. Most students will probably report a greater calculated length than directly measured length.

   b. It is difficult to straighten the segments of the leg for an accurate direct measurement.

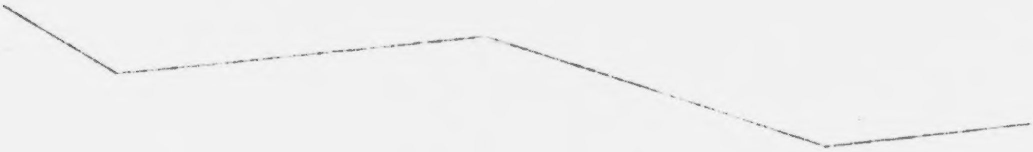
Related Activity

The student can use a piece of string, paper, or other flexible material to place around the abdomen of the grasshopper. The length around the abdomen can be indicated by placing a mark on the flexible material. The flexible material can be placed on the ruler and its length recorded.

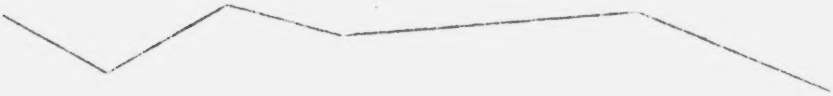
Assessment Task

Determine the total length of the following:

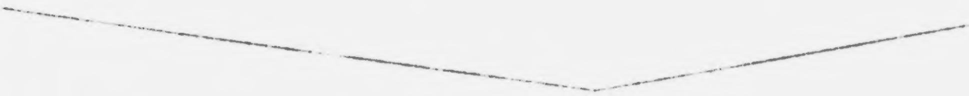
1.



2.



3.



Acceptable Responses

1. 157 mm to 161 mm or 15.7 cm to 16.1 cm
2. 130 mm to 134 mm or 13.0 cm to 13.4 cm
3. 144 mm to 146 mm or 14.4 cm to 14.6 cm

1B-15

BREATHING RATE OF A GRASSHOPPER

OBJECTIVES

Processes

11. Demonstrate a procedure for measuring time.

12. Demonstrate the ability to read a thermometer.

13. Demonstrate the ability to find an average.

Concepts

1. The breathing rate of an insect is dependent upon temperature.

2. Time rates can be determined by recording data for a long period of time and finding an average.

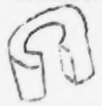
REFERENCES

Thurber and Kilburn. Exploring Life Science. p. 84

TEACHING SUGGESTIONS

Preparation

1. Time can be saved if the ice is crushed and the corks are split before class begins. One small bag of ice cubes per class is sufficient. A split cork allows fresh air to enter the test tube and enables the students to view the entire thermometer. The cork can be split as indicated in the diagram below.



2. Have students bring in live insects. Grasshoppers and crickets are ideal. They are readily available until the first heavy frost and they have large abdomens which can be viewed clearly.

Procedure

1. Each student group will need a timekeeper, one or more observers, and a person to record data.

2. It is not necessary that all groups test the breathing rate at the same temperatures. You may wish to assign specific temperatures, but there is a disadvantage in doing so: students may consume too much time in attempting to reach a specific temperature and fail to finish determining the breathing rate.

3. Draw a master data chart on the chalkboard and have the students record their data in the chart.

Responses to Interpretation Questions

1. If the counting is begun before the temperatures equalize, the temperature will continue to change and so will the count.

2. The insect's breathing rate is greatest at the higher temperature.

3. The insect's breathing rate is lowest at the lower temperature.

4. As the temperature increases, the breathing rate increases.

5. The prediction may be based on extrapolation, but students who understand the meaning of 90°C may predict that the insect will die.

EXTENDING OUR SENSES

OBJECTIVES

Process

14. Demonstrate the ability to select and use an appropriate instrument to extend observation.

Concepts

1. Scientists use a variety of instruments to make detailed observations.

2. It is important to be able to select and use the correct instrument for a specific observation.

Preparation

1. Provide materials in the following quantities: 10 plastic metric rulers, 5 compound microscopes, 10 slides, 3 stereoscopic microscopes, 3 hand lenses, 5 stop watches, 5 plastic tubes (length and diameter will depend on the insect), 5 scalpels, 10 petri dishes, 20 preserved grasshoppers, and 20 or more live insects.

2. Use large live insects such as grasshoppers, crickets, or beetles, if available. Otherwise, use the preserved grasshoppers and crickets.

Caution

Make sure the living insects are not ones that sting or bite.

Procedure

1. If possible, have the students work in pairs.

2. After the students have read the procedure in the student manual, allow them to select equipment they think necessary. Remind students to make only one observation at a time and to return equipment to the supply table as soon as they finish with it.

3. Explain a technique for preparing a slide of the compound eye of a grasshopper (Item 5). The eye can be examined by slicing a thin section and placing it in water on a slide.

Expected Results

Appropriate instruments for each part of the procedure:

1. metric ruler
2. metric ruler
3. hand lens or stereoscopic microscope
4. hand lens or stereoscopic microscope
5. ordinary microscope
6. ordinary microscope or stereoscopic microscope
7. hand lens or stereoscopic microscope
8. stop watch

Response to Interpretation Questions

1. a. ordinary microscope
   b. metric ruler
   c. stop watch
   d. hand lens or stereoscopic microscope
   e. hand lens, stereoscopic microscope, or ordinary microscope
   f. hand lens or stereoscopic microscope
2. A scientist uses instruments to extend his senses so that he can make more detailed observations.

Assessment Task

While on a field trip a group of students collected the following items:

a. pond water
b. fern leaf
c. three blades of grass
d. box turtle and a wood turtle

What instrument would you use to examine each item?

Acceptable Responses

a. microscope
b. hand lens or stereoscopic microscope
c. hand lens, stereoscopic microscope, or ruler
d. timer (to see which animal moved faster), hand lens, or ruler

HOW BIG IS THE CAGE?

OBJECTIVES

Process

15. Demonstrate a procedure for measuring volume.

Concepts

1. A volume measurement gives the quantity of space occupied by matter.

2. The volume of many regularly shaped objects can be computed by multiplying the area of the base by the height.

REFERENCES

Brooks et al. Modern Physical Science.

Swartz. Measure and Find Out, Book Two.

TEACHING SUGGESTIONS

Preparation

1. Part A of the investigation requires 30 cubes (each one equals one cm^3) per student group. A class divided into 20 groups needs 600 cubes.

2. In Part B, the rectangular solids can be cigar boxes, shoe boxes, chalk boxes, etc. Begin collecting the various rectangular solids a few weeks prior to the investigation. You need six different rectangular solids per group. Number them for identification.

Procedure

1. Hold up the large rectangular solid and pose the question, "How can you determine the amount of space occupied by this solid"? Students may suggest using small cubes that will fit into the solid. If a hint is needed, have students recall the covering technique used in 1A-14.

2. Distribute materials for Part A. Circulate to make certain students are forming rectangular solids. Be sure students realize that the total number of cubes used in constructing their rectangular solids is the same as the product of the number of cubes along Edge a, Edge b, and Edge c. Point out that volume is measured by selecting a standard unit and then counting the number of standard units needed to fill a certain space.

3. When students have completed the discussion of the interpretation items of Part A, distribute materials for Part B. Allow students adequate time to perform the calculations. Tell the students that the volume of many geometric solids can be calculated by using appropriate mathematical formulas.

4. For a follow-up activity, have students find in a reference the meaning of cubic centimeter, liter, milliliter, and graduate. Discuss the relationship of these terms. Two useful references are Pages 23-24 in *Measure and Find Out, Book Two*, and Pages 8-9 in *Modern Physical Science*.

Expected Results

The investigation should lead students to the understanding that volume of a rectangular solid may be obtained mathematically either by taking the product of three linear dimensions (length, width, and height), or by multiplying the area of the base by the height.

Responses to Interpretation Questions

Part A

1. They are the same.
2. Multiply length by width by height.

Part B

The values should be the same when compared. If they are not the same, an error in measurement was made. It should be pointed out that an error of only one centimeter in one dimension can result in a large error in the product. For example: If a rectangular solid measures 5 cm x 6 cm x 7 cm, the volume is 210 cm^3. An error of one centimeter in one dimension would result in a calculation of 168 cm^3.

Assessment Task

Use the assessment task described in 1A-13, "Measuring the Space that Matter Occupies."

IB-18

GRASSHOPPERS AND VOLUME

OBJECTIVES

Process

15. Demonstrate a procedure for finding the volume of an irregularly-shaped object.

Concepts

1. A volume measurement gives the quantity of space occupied by matter.

2. The volume of an irregularly-shaped object can be determined indirectly by the displacement of water.

REFERENCE

Heimler. Principles of Science. pp. 34-35

TEACHING SUGGESTIONS

Preparation

Soak the grasshoppers in water overnight.

Caution

Remind students not to touch their eyes with their fingers after handling the grasshoppers.

Procedure

Before beginning this activity, develop with the class the techniques for reading a graduated cylinder. This technique is illustrated in the reference.

Expected Results

1. A — 20 ml
B — 60 ml
C — 72 ml
D — 17 ml
E — 95 ml

Responses to Interpretation Items

Graduated Cylinder	Change in Water Level	Volume of Insect
A	2 ml	2 cc
B	3 ml	3 cc
C	6 ml	6 cc
D	1 ml	1 cc
E	27 ml	27 cc
F	9 ml	9 cc

2. E
   F
   C
   B
   A
   D

3. Five objects whose volume must be determined by using the method in this activity are a rock, a piece of wood, a small wad of paper, a pill bug, and a paper clip.

Related Activity

Give the students a regularly shaped object such as a small wooden cube, and have them determine its volume by two methods, water displacement and direct measurement.

Assessment Task

Have the students measure the volume of four irregularly shaped objects. If the students are working in pairs, each student should determine the volume of two objects. You will have to determine the volume of the objects prior to the assessment to establish what is an acceptable response.

1B-19

FOOD MASS

OBJECTIVES

Process

16. Demonstrate a procedure for measuring mass.

Concepts

1. Instruments are needed for making measurements.

2. A triple beam balance can be used to measure mass.

REFERENCE

Beauchamp, et al. Everyday Problems in Science, pp. 210-212

TEACHING SUGGESTIONS

Preparation

For each student group prepare a beaker containing fruit fly food. This fruit fly food is called Instant Drosophila Media and is listed on the science equipment order. Be sure that each beaker contains more than the 14 grams that is to be weighed. In a central location have a container in which students may put any excess medium.

Procedure

1. Develop with the class the proper technique for using the balance Make sure that all students understand this technique and have completed Item 1 correctly before they proceed.

2. When the students have completed their work collect the stoppered bottles, which are to be used in Activity 1B-20.

3. During the post-laboratory discussion mention analytical balances, which must be used to measure accurately masses less than one-tenth of a gram.

Response to Interpretation Question

a. volume measurement

Assessment Task

Select ten small objects such as a block of wood, a pair of scissors, a book, and the like. Number these, determine the mass of each, and make a key for your own use. Then distribute several objects to each student group. Have the students use triple beam balances to determine the masses of the objects. Acceptable responses might be within 0.5 gram of your own determinations.

REARING FRUIT FLIES

OBJECTIVES

Process

17. Demonstrate a procedure for culturing fruit flies.

Concepts

1. Scientists have developed specific techniques for culturing and handling in their laboratories animals that are useful for research.

2. The sexes of fruit flies can be distinguished by characteristics of the abdomens.

TEACHING SUGGESTIONS

Preparation

1. At least one week before beginning this work, order three bottles of fruit flies per class from Arbutus Junior High School (telephone: 242-2900).

2. Before each class begins, anesthetize the flies. First, transfer the flies into an empty container. (This prevents them from falling into the moist food when they are anesthetized.) If petroleum ether is used, the following is suggested: Place some ether on a piece of cotton that is large enough to stopper the bottle. Watch the flies and remove the plug as soon as the last flies are anesthetized.

3. Another method to immobilize the flies: place the bottle of flies in a refrigerator for at least one hour.

4. Because some of the flies may revive as the students are working with them, provide a petri plate that has a piece of cotton taped to the inside. Put a few drops of ether on the cotton. Tell the students to place the device over any fly that becomes active.

5. Provide a large bottle for receiving excess flies. (See Item 8 of Procedure in student manual.)

Procedure

1. Review the method for distinguishing between male and female fruit flies.
2. Explain the procedure used in anesthetizing the flies.
3. Distribute the materials. For each student group, place 6 or 7 flies on a piece of paper. Tell the class that some groups may get all males or all females. If this happens, tell them to exchange with another group. Have available the petri dish and container mentioned in Items 4 and 5 under Preparation.
4. Tell the students to place several additional flies in the bottle if some of the first ones do not revive within fifteen minutes.
5. Have the students label their bottles with masking tape.
6. Place the bottles in a location where students can observe the flies periodically.
7. At the conclusion of the laboratory work, discuss the life cycle of the fruit fly. The following information may be helpful:

> Many insects go through four life-cycle stages. These stages are: 1) egg, 2) larva, 3) pupa, and 4) adult. Fruit flies are among the insects that have these four stages. Adult female can lay eggs when two days old, and continue to lay eggs until they die. The sperm, which has been stored by the female since mating, enters the egg before it is laid. The egg can be identified as a small, white, oval object with two filaments on one end. It takes one day for the egg to hatch into a larva. Each larva sheds its outer layer (molts) twice during the larval period to allow room for its body to grow. Larvae are very active and have large appetites. They eat their way through the media causing tunnels. This network of tunneling is called "working." Looking for tunneling is a very simple way of checking to see if eggs are hatching and a new generation is developing successfully. If no tunnels are seen, then there are probably no larvae. The larva's black mouth parts can be seen moving back and forth in the media. The average length of time for the larval and pupa stages is approximately seven days each. When larvae are about to pupate, they crawl out of the medium. The paper strip is provided so that they may have a place to pupate.

Response to Interpretation Questions

1. Flies are handled more conveniently when anesthetized. When awake, they are too active and fly away.

2. Fruit flies are delicate insects. Handling with fingers or forceps can crush them. The barbs on the legs of the flies cling to the bristles of the brush and allow the flies to be moved without harming them.

Assessment Task

Distribute about a dozen anesthetized flies to each group and have the students determine the number of male and female flies. Have groups exchange flies to check their results.

1B-21

CRICKET CHIRPS

OBJECTIVES

Processes

18. Construct a chart of paired measurements.

19. Construct a chart of paired measurements after first ordering one of the sets of measurements.

20. Distinguish the dependent variable from the independent variable, given a chart of paired measurements with one of the sets of data ordered.

Concepts

1. Charts are a good method of organizing data.

2. Ordered data is easier to assess than non-ordered data.

3. All data supplied may not be pertinent to a given problem.

4. As temperature increases, crickets chirp more rapidly.

5. An approximate determination of temperature can be made by applying this rule. The number of chirps per 15 seconds plus 39 equals the temperature.

REFERENCE

ERC. Life Science, Variation. p. 61

TEACHING SUGGESTIONS

Procedure

1. Have the students read the introductory paragraph in the student manual to learn the purpose of the activity. You may want to discuss how cricket chirps are made.

2. Have the students read the selection "Cricket Chirps," and complete Items 2 and 3 only.

3. Have several students put their charts on the board for checking. Be sure all students have correct charts before they continue with Items 4, 5, 6, and 7.

4. When all students have completed Item 7, review the meaning of dependent and independent variables. Relate these to "chirps per minute" and "temperature" in this instance. Have the students examine the numerals and intervals on the horizontal and vertical axes. Discuss why these were used. A projected transparency of the grid is helpful in this discussion.

5. Explain how to plot points on a graph and have the students complete Item 8.

Response to Interpretation Questions

1. As the temperature increases, the number of chirps increases.

2. a. 51 b. 21 c. 1

3. The number of chirps per 15 seconds plus 39 equals the temperature. (This rule applies to field crickets which are very sensitive to temperature change.)

Assessment Task

Use the assessment task described in 1A-23, "Relationship Between Mass and Volume: Part II."

TIMING THE DEVELOPMENT OF FRUIT FLIES

OBJECTIVES

Processes

21. Construct a line graph from a table of data.

22. Construct one or more ideas from a set of observations.

Concept

The emergence of fruit flies from the pupa stage is affected by light.

REFERENCE

Demerec and Kaufmann. Drosophila Guide.

TEACHING SUGGESTIONS

Procedure

1. Review the construction of a line graph. Be sure to include dependent variable, independent variable, determination of intervals, and plotting points.

2. It may be desirable to begin this line graph as a class activity. An overhead projector may be used or a grid may be drawn on the chalkboard. Have the entire class determine the two variables, their locations on the grid, and the intervals. Plot several points before having the class complete the graph.

3. When most of the students have completed their graphs, ask several students to plot the remaining points on the chalkboard grid. Tell the students to compare their graphs to the finished chalkboard graph.

4. In the discussion it is important to stress that a graph is data in picture form.

Responses to Interpretation Questions

1. The fewest flies emerged at 2 a.m. and 3 a.m.
2. The largest number of flies emerged between 10 a.m. and noon.
3. Light seems to affect the emergence of fruit flies from the pupae, since most emerged while light was present and few emerged during the hours of darkness.

4. Students may answer either way, depending upon the justification of their answers.

   No. The flies would begin to emerge soon after the light source was turned on and the number would probably increase for several hours before tapering off.

   Yes. The results would be the same because the number of flies emerging from the pupa is determined by the time it takes for a fly to become fully developed.

Assessment Task

Give each student a table of data as follows:

Population of Paramecium per Cubic Centimeter

Day	Number of Paramecium
Sept. 1	0
2	12
3	27
4	52
5	54
6	55
7	30
8	20
9	14
10	9

Construct a graph using the above data. Write a short paragraph explaining the graph.

PICTURING DATA

OBJECTIVES

Processes

21. Construct a line graph from a table or graph.

23. Construct one or more ideas from a table or graph.

Concept

The purpose of a graph is to show data quickly and clearly.

REFERENCE

BSCS. Biological Science, An Inquiry Into Life. p. 706

TEACHING SUGGESTIONS

Procedure

1. Have the students read the introductory statement and Item 1.

2. Show how two line graphs can be constructed on the same grid by using an example other than that suggested in this activity.

3. Have the students complete the graph and the interpretation items.

4. Stress the advantages of the graph as compared with the chart. If time permits, discuss other examples of predators and prey in the animal world.

Response to Interpretation Questions

1. Grasshoppers could have hatched about May 1 or some grasshoppers could have migrated into the area about May 1.

2. The sudden appearance of the swallows indicates swallows probably migrated into the area about June 1.

3. Grasshoppers probably disappeared because of the cold weather.

4. The swallows probably migrated from the area.

5. Some students will probably infer that the swallows were feeding on the grasshoppers since the number of grasshoppers decreased with the appearance of the swallows.

6. Responses will vary but should be supported by the graph.

7. A severe drought would probably cause a decrease in the number of grasshoppers and swallows.

IDEAS FROM GRAPHS

OBJECTIVES

Process

23. Construct one or more ideas from a table or graph.

Concepts

1. Data can be expressed in charts or several types of graphs.
2. One or more statements can usually be made about any set of data.

TEACHING SUGGESTIONS

Procedure

1. Prepare for projection transparencies of several graphs and charts similar to those used in this activity. With these develop skills in writing statements explaining what a set of data shows.
2. Have the students read the introductory statement and carefully examine the six charts and graphs.

Expected Results

1. Insect breathing rate increased as the temperature increased.
2. The number of eggs laid by a female varies among different kinds of insects.
3. With each trial the roach increased his speed through the maze.
4. As the quantity of food increased the number of grasshoppers increased.
5. Grasshoppers were found between April and October.
6. Jaws of the male beetles were longer than those of the female beetles.

Responses to Interpretation Questions

More than one statement can be made from a graph or chart. Some examples are:

Chart #2

Wasps lay fewer eggs than cockroaches.

Chart #5

a. Grasshoppers were present during the warm months.

b. There were no grasshoppers in January.

c. The number of grasshoppers increased from April to June.

Chart #6

Measurements of the same beetle jaw varied from one student group to another.

Assessment Task

Collect some graphs and charts from newspapers. Duplicate and hand out. List a number of statements under each graph or chart, one of which is correct. Have the students identify the correct response.

1B-25

SUPPORTING IDEAS WITH DATA

OBJECTIVES

Process

24. Identify the data that supports an idea.

Concept

It is important to know when a graph supports or fails to support an idea.

TEACHING SUGGESTIONS

Preparation

Make transparencies of any two graphs for overhead projection.

Procedure

1. Begin by projecting two graphs. Make a statement that is supported by one graph but not the other. Ask the class to select the graph that supports the statement. It may be necessary to use several pairs of graphs and several statements before asking the class to begin work on 1B-25 in the student manual.

2. When the students have completed their individual work, have several students explain why they chose a particular graph for each item. Stress the concept stated in the objectives.

Expected Results

1. Graph C
2. Graph A
3. Graph B
4. Graph D

ARRANGE IN ORDER

OBJECTIVES

Process

25. Order a list of ideas from least to most probable.

Concept

The selection of the most reasonable ideas from a list of many possible ideas is an important part of the work of a scientist.

REFERENCE

Zim. Insects.

TEACHING SUGGESTIONS

Procedure

1. Discuss the title and what is meant by ordering ideas. Have each student complete his individual work in the student manual.

2. Discuss the results and the interpretation items.

Expected Results

Group I	Group II
1	2
3	1
2	3

Responses to Interpretation Questions

1. A scientist is often confronted with several causes for a certain situation. In reaching a decision, he must choose the most probable cause from a group of possible causes. He then has a basis for an efficient program of experimentation. Put another way: if you observe a large hole in your gas tank, it is best to repair the hole before checking the spark plugs.

2. It is easier to distinguish between ordering by size and time than ordering from the least to most probable since instruments can be used to measure time and size, but ordering by probability is largely a matter of judgment.

Related Activity

If you wish to simplify this for some students, direct them specifically to read about Mormon crickets, the European corn borers, and the grasshoppers. Ask them to select the "culprit" from among these three insects.

> The European corn borer is the "culprit". The reasons, arranged in order of importance are:
>
> 1. It is found in this area.
> 2. It feeds on garden crops such as corn.
> 3. It is difficult to control.

1B-27

COMBATING INSECT PESTS

OBJECTIVES

Process

26. Distinguish whether or not an idea is supported.

Concepts

1. The control of insects is of economic importance to man.
2. Man has learned many ways to control insects.

REFERENCE

Popular Science. Combating Insect Pests. (Filmstrip)

Fichter. Insect Pests.

TEACHING SUGGESTIONS

Preparation

Preview the filmstrip.

Procedure

1. Discuss the introductory paragraph with the class. Ask students to name any insect pest with which they are familiar.
2. Show the filmstrip and tell students that they should list only ideas that support the statement: "Man has learned many ways to control insects." Have the students complete the interpretation items.
3. In discussing the interpretation items, stress insect examples that are of local importance and known to the students.

Expected Results

Proper sanitation, chemical spraying, poisons, mechanical devices, and getting rid of breeding places are methods used to control insects.

Responses to Interpretation Questions

1. House flies, mosquitos, and tsete flies carry disease germs; termites destroy wood structures; grasshoppers destroy crops; moths destroy clothing; lice cause irritations; fleas cause irritation and carry germs.

2. The most important measure in controlling insects is proper sanitation.

3. Insects cost man billions of dollars annually, but there is no method to compute exactly how much the loss is.

4. An individual can help to eliminate mosquitos by not permitting any water to become stagnant.

Assessment Task

"Grasshoppers are typical insects."

In the list below, check only the statements that support the idea.

1. Grasshoppers have six legs.
2. Grasshoppers have very large jumping legs.
3. Grasshoppers have three body segments.
4. Grasshoppers secrete a brown digestive juice for protection.
5. Grasshoppers have two eyes.
6. Grasshoppers have a pair of antennae.

Acceptable Responses

The correct responses are 1, 3, and 6.

Related Activity

Ask a student to prepare a book report on The Silent Spring by Rachel Carson. Other students can report on some of the current news articles about insecticides and their possible harm to man.

1B-29

THE COOL FRUIT FLY

OBJECTIVES

Process

27. Construct an investigation and demonstrate the procedures to test an idea.

Concept

Fruit flies become inactive when temperature is lowered.

TEACHING SUGGESTIONS

Procedure

1. Have the students read the introductory statements.

2. If some of the students are having-difficulty planning an investigation, it may be helpful to identify some basic steps that should be considered such as identifying the problem, deciding on a procedure, establishing controls, selecting materials, reading for background information, collecting and recording data, and the like.

3. Try to provide most of the materials that the students will need. In some cases the students may want to bring in materials from home.

4. After students have had time to carry out their work, have each group report on the procedure used and the temperature required for inactivating the fruit flies.

   Record on the chalkboard the temperatures reported and compute an average.

5. Discuss possible procedures for determining effects of temperature changes on other animals.

Expected Results

The students' plans may vary but essentially they will be placing fruit flies in containers, cooling the containers, and observing the temperature at which the fruit flies become inactive. Fruit flies become inactive at about 10° C.

INSECT CLASSIFICATION

OBJECTIVES

Process

27. Construct an investigation and demonstrate the procedures to test an idea.

Concepts

1. Insects have a wide variety of structural characteristics.
2. Insects are classified according to their characteristics.

REFERENCE

Thurber and Kilburn. Exploring Life Science. pp. 55-59

TEACHING SUGGESTIONS

Preparation

Have students bring in their insect collections.

Procedure

1. Begin by discussing hobbies such as stamp collecting. Relate this hobby to the idea of classification by having the students determine how stamps might be classified. For example, stamps could be arranged in groups according to country, shape, color, or cost.

2. Have students read the introductory statement and begin their work.

3. If the collections made by some students are small, two or three students might combine their collections and work as a group.

4. If some students are having difficulty, have one or two of the more successful ones put on the board their list from Item 2 of the Procedure in the student manual.

Expected Results

Students will probably use color, size, shape of wings, number of wings, texture of wings, mouth parts and eyes.

Response to Interpretation Questions

1. A classification system for insects is important because it can be used to identify insects easily.
2. Medical researchers, chemists, and botanists might use the classification system.
3. External structures such as shape, size, appendages, color and texture are important in classifying insects.
4. Color, movement and eating habits are characteristics of live insects that could be used for classification.

MATERIALS AND EQUIPMENT

Option B

1B-1. The Search

overlay of optical illusion, 1
apple, 1

Goldstein. *How to Do an Experiment*.

1B-2. Insects Invade Farm

crickets, preserved, 40

1B-3. Observing Insects

plastic vials with caps, 40
live insects, 40
grasshopper, preserved, 1

1B-4. What Is an Insect?

grasshoppers, preserved, 40

Thurber and Kilburn. *Exploring Life Science.*

Zim. *Insects.*

1B-5. Characteristics of Insects

Thurber and Kilburn. *Exploring Life Science.*

Zim. *Insects.*

1B-6. Insect Collecting

scissors, 20
insect pins, 500
collecting nets, 10
plastic cups, 40
plastic cup lids, 40

Thurber and Kilburn. *Exploring Life Science.*

Siverly. *Rearing Insects in School*.

De Waard. *What Insect is That?*

1B-7. Pill Bugs in a Pill Box

plastic boxes with lids, 10
scissors, 10
black paper, 8½"x11" sheets, 10
tape, 1 roll
timers, 10
hand lenses, 10
pill bugs, 50

Thurber and Kilburn. *Exploring Life Science*.

1B-8. A Closer Look at Insects

metric rulers, 40
hand lenses, 40
insects provided by students

1B-9. The Parts of a Microscope

compound microscopes, 20
hand lenses, 40

Brandwein. *Life, Its Forms and Changes*.

Keen. *How and Why Wonder Book of the Microscope.*

1B-10. Learning About the Microscope

Silver Burdett. *Using the Microscope - Part I* (filmstrip)

1B-11. Using a Microscope

"e's" from a newspaper, 40
compound microscopes, 20
eye droppers, 20
microscope slides, 40
cover slips, 40
lens paper, sheets, 10
grasshoppers, preserved, 10
razor blades, 20
transparency of microscope, 1

1B-12. Stereoscopic Microscope

stereoscopic microscopes, 20
"e's" from a newspaper, 40
microscope slides, 40
cover slips, 40
lens paper, sheets, 20
eye droppers, 20
prepared slides, thread, 20
fruit flies, 1 bottle

1B-13. Measuring Length

meter sticks, 20

Miller. *Understanding the Metric System.*

1B-14. Length of Grasshopper Legs

metric rulers, 40
grasshoppers, preserved, 40
paper towels, 1 pkg.

1B-15. Breathing Rate of an Insect

beakers, 250 ml, 10
ice cubes, 1 bag
test tube 25 x 200, 10
stoppers for 25 x 200
  test tubes, 10
timers, 10
thermometers, 10
stirring rods, 10
paper towels, 10
heat sources, 10
stands, 10
asbestos mats, 10
live insects, grasshoppers, 10

1B-16. Extending Our Senses

metric rulers, 20
compound microscopes, 10
stereoscopic microscopes, 10
hand lenses, 10
microscope slides, 20
cover slips, 20
razor blades, 5
grasshoppers, preserved, 20
timers, 5
plastic tubes, 3', 5
petri dishes, 10
paper towels, 1 pkg.
fruit flies, 10

1B-17. How Big Is the Cage?

centimeter cubes, 300
rectangular solids, 60
metric rulers, 10

1B-18. Grasshoppers and Volumes

graduated cylinders, 100 ml, 40
grasshoppers, preserved, 20
irregularly shaped objects, 20

1B-19. Food Mass

triple beam balances, 20
beakers, 250 ml, 20
stirring rods, 20
Drosophila mix, 150 grams
culture bottles, 20
stoppers for culture bottles, 20
dry yeast, 1 oz.
graduated cylinders, 20
dimes, 10
nickels, 10
pennies, 10

1B-20. Rearing Fruit Flies

hand lenses, 20
bottles of food, 20
metric rulers, 20
scissors, 20
small paint brushes, 20
fruit flies, 3 bottles
paper towels, 1 pkg.

1B-21. Cricket Chirps

none

1B-22. Timing the Development of Fruit Flies

metric rulers, 40

1B-23. Picturing Data

none

1B-24. Ideas From Graphs

none

1B-25. Supporting Ideas with Data

none

1B-26. Arrange in Order

Zim. *Insects*.

1B-27. Combating Insect Pests

Zim. *Insects*.

Combating Insect Pests, Popular Science F.S. #570 (filmstrip)

1B-28. The Cool Fruit Fly

beakers, 250 ml, 15
crushed ice, 1 bag
stirring rods, 15
thermometers, 15
test tubes, 25 x 200, 15
corks to fit test tubes, 15
timers, 15
paper towels, 1 pkg.
heat sources, 15
marking pencils, 15
fruit flies, 3 bottles
asbestos pads, 15
cork borer, 1

1B-29. Insect Classification

student insect collections, all
hand lenses, 40

Thurber and Kilburn. Exploring Life Science.

PHASE TWO. DEVELOPING A MODEL OF MATTER

Overview

In Phase Two students observe the behavior of matter as a basis for developing a model of matter.

In Investigations 2-1 to 2-5 sedimentation, filtration, and chromatography provide evidence that some kinds of matter can be separated into component parts. Then in 2-6 students are introduced to the use of models for studying systems that cannot be readily observed. This sets the stage for a series of activities that ends with an invitation to the students to construct their own model of matter.

Investigations 2-7 to 2-19 enable students to observe various ways in which matter behaves; e.g. diffusion, adhesion, cohesion, and effects of heating. This block of investigations is organized randomly. Eventually the students are asked to classify their observations according to similarities in the ways matter behaves. Titles do not reveal the nature of the property being observed; they are merely a convenience to enable students to identify the investigations.

When students have completed Investigations 2-7 to 2-19 they are ready to begin the next step in developing a particle model. They search through their investigations for similarities in behavior of matter. When they find two or more investigations showing a similar behavior they should group these together. It has been found from past experience that the following classification scheme leads most directly to the development of the tenets of the particle model of matter.

Group 1

Dye and Water (2-8)
The Unknown in a Bag (2-13)
Swirling Smoke (2-15)
Observing Filter Paper (2-16)

Group 2

Heating and Cooling a Liquid (2-7)
Ball and Ring (2-10)
Ice Cubes (2-14)

Group 3

Paper Towel in Water (2-9)
Glass Slides and Water (2-11)
A Paper Clip and Water (2-12)
A Set of Glass Tubes (2-18)

Group 4

Alcohol and Water (2-17)
An Unusual Balloon (2-19)

In this classification scheme the investigations in Group 1 relate to particles moving; those in Group 2 relate to particles moving farther apart when heated and closer together when cooled; those in Group 3 relate to particles exerting forces; and those in Group 4 relate to spaces between particles.

Once the investigations have been classified, students should examine each group of investigations and attempt to explain the behavior in terms of particles. The class can be divided into groups for this activity. Through class discussion the students can formulate a particle model of matter. It is very possible that the students will not come up with all of the five tenets of the particle model. Further, it is possible for the class to develop a useful particle model even though it may not be exactly the same one described here. It is not as important to develop a model that is scientifically complete as it is to give students the experience of developing a model that explains the behavior that they have observed.

For students of low average or below average ability it may be difficult to do the investigations randomly and then classify them into groups showing similar behavior. Instead the students might perform the investigations in an order such that all of those occurring in Group 1 are performed together. After these have been performed, students could look at them for similarities in behavior, and attempt to make hypotheses to explain the behaviors. Next students could perform and discuss the investigations in Group 2. This could be continued until all investigations have been performed and a hypothesis has been suggested for each group of investigations.

In Investigation 2-21 the students attempt to develop explanations for the behavior of matter in each major grouping. Through a combination of the student explanations, a particle model of matter can be developed. Hopefully, the following points would be included:

1. All matter is composed of very small particles.
2. There are spaces between particles.
3. Particles are always in motion.
4. Particles move farther apart when heated; they move closer together when cooled.
5. Particles exert force.

In Investigations 2-23 to 2-27 students extend the model by decomposing compounds into simpler substances. The distinction between compounds and elements is summarized in Investigation 2-28.

In Investigations 2-29 and 2-30 the students use two techniques to verify the existence of small particles. In Investigation 2-29 particles are detected by a simple procedure of removing them by friction (rubbing); their existence is further verified in Investigation 2-30 by using a voltmeter as a simple particle detector. This instrument records the movement of particles due to a chemical reaction. Finally in their search for structure, the students are led to the development of a molecular-atomic model of matter:

1. Molecules (same as particles used in the first model) are made up of one or more smaller particles called atoms.

2. Atoms have a small dense inner mass (nucleus) surrounded mostly by empty space.

The processes developed in Phase One are reinforced as the students work through the investigations in Phase Two. At the same time a series of ideas about the nature of matter is developed. These ideas are listed below more or less in the sequence in which they are presented to the students.

SEQUENCE OF CONCEPTS

1. Substances can be separated from a mixture by (a) manual separation based on color or shape, (b) magnetism, (c) sieving, and (d) filtration.

2. The settling rate of particles is determined in part by size.

3. When sediments are deposited by water, the larger particles are usually on the bottom and the smaller ones on the top.

4. Solid substances vary in their ability to dissolve in liquids.

5. Mixtures of some (but not all) solids can be separated by filtration.

6. Dissolved solids can usually be recovered from filtrates by evaporation.

7. Some dyes can be separated into substances having different colors.

8. A model makes possible the study and understanding of something that cannot be directly observed.

9. When a liquid is heated it expands; when a liquid is cooled it contracts.

10. When placed in water dye spreads throughout the water.

11. When a strip of porous material is placed in a liquid, the liquid may travel up the strip.

12. When a solid is heated, its volume increases; when a solid is cooled its volume decreases.

13. When water is placed between two clean pieces of glass they stick together.

14. Under some circumstances objects made of substances that ordinarily sink can be made to rest on the surface of the water.

15. Some substances can be identified at a distance by their odors.

16. When a gas from hydrochloric acid and a gas from ammonium hydroxide solution come in contact there is evidence of a change.

17. It is possible to observe by indirect means the movement of a substance from one place to another.

18. When equal volumes of water and alcohol are mixed, their combined volume is less than the sum of their separate volumes.

19. The levels of liquids in capillary tubes vary according to the kinds of liquid and according to the diameters of the tubes.

20. When a partially filled balloon is placed in a vacuum, the balloon expands.

21. Many physical properties of matter can be explained by a particle model.

22. The behavior of matter indicates that there are spaces between the particles.

23. The behavior of matter indicates that particles move.

24. The behavior of matter indicates that particles move farther apart when heated and move closer together when cooled.

25. The behavior of matter indicates that particles exert force.

26. A substance may be decomposed into two substances different from the original substance and from each other.

27. Gas A (oxygen) is colorless, odorless, tasteless, heavier than air, and supports combustion.

28. Some gases are lighter than air.

29. Some gases are combustible.

30. Liquid Y can be decomposed into two gases by passing an electric current through it.

31. Compounds can be chemically broken down into simpler substances.

32. Elements cannot be chemically broken down into simpler substances.

33. Particles can be removed from matter by rubbing.

34. Matter is electrical in nature.

35. Electricity may be obtained from compounds and elements.

36. Atoms are made of smaller particles.

37. An atom has a dense inner mass surrounded by mostly empty space.

38. A model is based on both evidence and assumptions.

39. Molecules are made up of one or more simpler particles called atoms.

40. An element is composed of atoms of the same kind.

41. Compounds are formed when two or more different kinds of atoms join together.

42. An atom has a dense inner mass surrounded by mostly empty space.

2-1

SEPARATING A MIXTURE

OBJECTIVES

Processes

1. Name the qualitative characteristics of objects using one or more of the senses. (3)

2. Demonstrate the ability to classify according to size, color, shape, and magnetic property. (15a)

Concept

Substances can be separated from a mixture by (a) manual separation based on color and shape, (b) magnetism, (c) sieving, and (d) filtration.

REFERENCES

Brandwein, et al. Exploring the Sciences. pp. 77-78
Herron and Palmer. Matter, Life, and Energy. p. 45

TEACHING SUGGESTIONS

Preparation

1. In 20 plastic vials place a portion of a mixture of the following substances, making sure that some of each substance is present in each vial:

   - iron filings
   - salt crystals
   - finely chopped cork
   - sugar crystals
   - washed pebbles
   - colored sand or grit

   Other substances can be substituted for the above.

2. For the assessment task, make a mixture of the following:

   - sawdust
   - salt crystals
   - white sand
   - iron filings
   - rice
   - steel shot

   Other substances may be substituted, provided there is partial but not complete overlap with the first mixture.

Caution

For safety reasons tell students not to taste any of the substances.

Procedure

1. This activity is an introduction to methods for separating mixtures of substances. Emphasis should be on the methods used, not on the substances being separated. Tell the students to read the investigation. Distribute the vials and have the students complete Procedure Items 1 and 2. Do not suggest any separation scheme to the class.

2. Collect the suggested plans and evaluate them overnight so that appropriate equipment can be made available to the students. Be sure that procedures and equipment are safe and within range of student abilities.

3. The following day have students carry out the investigation they have designed, listing their procedures and results.

4. On the third day ask four or five different students to list on the chalkboard the procedures they used. Follow with a class evaluation and make a class list of the most successful procedures. Ask each student to compare his procedures with the class list and add to or modify his list where necessary.

Expected Results

Each student should be able to devise a plan and apply techniques for separating some of the substances found in the mixture; for example, pebbles by size and feel, cork by color, and iron by its magnetic property. They will tend to confuse sugar and salt if water is added to the mixture.

Assessment Task

Distribute vials containing a mixture of substances not previously used. Provide students with the necessary equipment for separating the mixture. The student should be able to separate the substances in the mixture.

Related Activity

Ask a few students to bring in some naturally occurring mixtures, such as soil, for interested members of the class to separate.

2-2

SEPARATING SUBSTANCES BY SEDIMENTATION

OBJECTIVES

Processes

1. Order particles by size.
2. Demonstrate the ability to find averages.
3. Describe the arrangement of different-sized particles that have been placed in water. (13)
4. Construct a graph comparing settling time with particle size. (21)
5. Construct one or more ideas from a table or graph. (23)

Concepts

1. The settling rate of particles is determined in part by size.
2. When sediments are deposited by water, the larger particles are usually on the bottom and the smaller ones on the top.

REFERENCES

ESCP. Teachers' Manual. pp. 357-358
Thurber and Kilburn. Exploring Earth Science. pp. 290-293

TEACHING SUGGESTIONS

Preparation

1. Read the ESCP reference for a more detailed explanation of this investigation.
2. Sieve a mixture of sand, silt, clay, pebbles, and gravel to obtain samples of each as uniform in size as possible. Prepare for each student group 5 half-filled vials, each containing a different sample of the previously sorted mixture.

3. To conserve time, set up the plastic columns and ring stands before the class session.

4. Obtain metal shot for practicing dropping and timing techniques.

Cautions

1. Make sure the rubber stoppers on the plastic columns are watertight. Frequently, fine grains of sand lodge between the rubber stopper and the plastic column, permitting the water to run out.

2. Caution the students not to force the rubber stopper too hard into the column as this may cause the column to crack.

3. Set the bottom of the column on the ring stand base. Tell the students to be cautious when moving the set-up, keeping one hand on the base and the other on the column.

4. To avoid overflow, check that the columns are not completely filled with water.

Procedure

This investigation is designed to give students an opportunity to invetigate one method of separating materials. They will compare and graph the relationship between particle size and settling time.

1. Discuss the procedure with the class. Have the students speculate on the particle size - settling possibilities. Tell the students that the purpose of the investigation is to verify their predictions.

2. Provide metal shot for students to use to practice timing and dropping techniques.

3. It may be necessary to review with some students the method for finding averages. A sample chart and graph on the chalkboard or overhead may also be helpful.

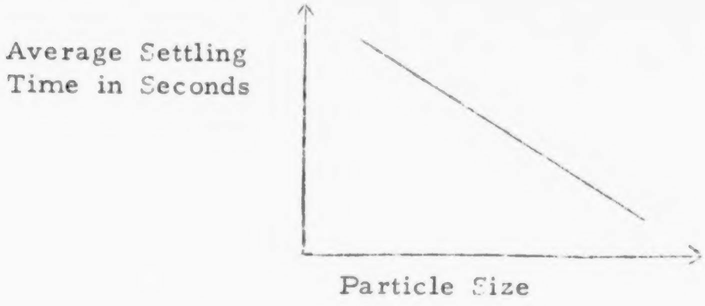
4. After the investigation has been completed, begin the post-laboratory discussion by reviewing the

procedure. Continue with a discussion and interpretation of the graph.

5. After the interpretation questions have been discussed, drop a mixture containing particles of various sizes into the plastic column. Compare the results with the prediction made by the class.

Expected Results

1. The time required for particles to settle should decrease as the size of the particles increases.
2. The typical student graph of settling time as a function of particle size is shown below:



Responses to Interpretation Questions

1. The largest particles fell fastest. The smallest particles fell slowest.
2. As the size of particles increases the settling time decreases.
3. The sketch should agree with the answer given in Interpretation Item 2: large-sized particles on the bottom and the smaller ones on top.

Assessment Task

Given five particles of various sizes the student should be able to predict relative settling time and diagram the settled strata. Acceptable responses would show the settling times increasing as the sizes of the particles decrease. If a diagram is requested, it should show larger particles on the bottom and smaller particles on the top.

Related Activity

If time permits, show illustrations of graded bedding strata and discuss the implications of this investigation on the formation of such strata.

2-3

SEPARATING SUBSTANCES BY FILTRATION

OBJECTIVES

Processes

1. Name the qualitative characteristics of events, using one or more of the senses. (3)
2. Describe the appearance of sand, sugar, and calcium carbonate. (13)
3. Construct one or more ideas from a set of observations. (24)
4. Construct a laboratory set-up from a diagram.
5. Distinguish between a filtrate and a residue.

Concepts

1. Solid substances vary in their ability to dissolve in liquids.
2. Mixtures of some (but not all) solids can be separated by filtration.
3. Dissolved solids can usually be recovered from filtrates by evaporation.

TEACHING SUGGESTIONS

Preparation

1. Have enough of the following pieces of equipment for each group:

   ring stand
   ring clamp
   test tubes,
     18 x 150 mm, 5
   watch glass
   rubber stopper, solid, #1
   filter paper, 5 pieces
   funnel
   beaker, 250 ml

If the funnel is too small to be supported by the ring clamp, use a triangle on top of the ring. Masonite pegboard and clips can be used in place of the ring stand, ring clamp, and burette clamp.

2. For each student group prepare three test tubes (or vials) containing a 2 cm depth of sand, sugar, or calcium carbonate respectively. Label the containers, e.g. 1A, 2A, or 5A, where each number represents the part of the investigation in which the container is to be used and the letter represents the class group.

Caution

Use calcium carbonate powder, not calcium carbonate chips.

Procedure

This investigation is designed to teach the students how to separate substances by filtration. It also shows that solids vary in their solubility in water.

1. Have the students read the procedure to find the distinction between a filtrate and a residue.

2. Demonstrate how to fold a piece of filter paper and how to wet it to keep it in the funnel.

3. Have each student group label its watch glass with its group letter.

4. By the end of the first session Procedure Items 1, 2, and 3 should be completed and the equipment set up for Item 4. Items 4, 5, and 6 may be completed on the second day.

5. Use the interpretation questions and the concepts as a basis for class discussion.

Expected Results

Sand: Students should be able to separate the sand from the water. They should indicate on the chart that sand is a residue.

Sugar: Students should find it difficult to separate sugar from water using the filtering technique. They should indicate on the chart that sugar is part of the filtrate.

Calcium carbonate: This substance is used because it is partially soluble. Therefore part of the sample filters out of the water, but some remains in the filtrate. The filtrate is very cloudy at first. Twenty-four hours later the water evaporates leaving a grayish-white powder.

Responses to Interpretation Questions

1. The filter paper separates the sand from the water.

2. The filter paper allows both the water and the sugar to pass through it.

3. The filter paper separates most of the calcium carbonate from the water.

4. No. This was observed in the sugar-water filtrate. The sugar still was not removed.

5. Add water to a test tube containing sand and sugar. Cover the test tube and shake it. Pour the mixture into a funnel lined with filter paper. Pour the filtrate in a watch glass and allow it to stand overnight. The sand can be found in the filter paper and the sugar in the watch glass.

SEPARATING SUBSTANCES BY CHROMATOGRAPHY

OBJECTIVES

Processes

1. Construct a laboratory set-up from a diagram.
2. Demonstrate a procedure for separating small particles of matter.

Concept

Some dyes can be separated into substances having different colors.

REFERENCE

Joseph, et al. A Sourcebook for the Physical Sciences. pp. 296-297

TEACHING SUGGESTIONS

Preparation

1. Cut the strips of chromatography paper allowing extra strips for students who make errors. The size of the bottle is not important; however, the chromatography paper should be cut into strips as long as the height of the bottle to be used. If chromatography paper is not available, use filter paper.
2. Place a dot of green food coloring about 2 cm from one end of each strip of chromatography paper. Use an old fountain pen, stylus, or fine pipette to place the dot on the paper. Use a small amount of coloring so that the dot does not smear. The separation is best if the dot is dry before starting.

Caution

Some green food colorings will not separate. Test the brand you have before starting the investigation.

Procedure

1. Have students read the procedure. Question sufficiently to determine that the directions are understood.

2. Remind students not to let the green dot touch the surface of the water.

3. Have students determine if each color traveled the same distance on each paper strip. This can be accomplished by pinning samples of the strips to the bulletin board and comparing them visually. All strips must be pinned so the original drops of coloring are at the same horizontal level. Then if each strip was run for the same length of time, the same separated colors should appear at the same level on all strips.

Assessment Task

Given a sample of black washable ink, the student should demonstrate a procedure for separating the ink into several different colors. In the assessment task a student can use the same procedure that was used in the investigation. Students should be able to separate and name the red, blue, and yellow colors. Incomplete separation may produce green in some ink samples.

Related Activity

Have some students determine what happens when several dried paper strips containing only the separated colored portions are soaked in 1 or 2 ml of water in a small test tube. The result of this soaking should be the original color of whatever dye was used but the intensity will be less.

ASSESSMENT TASK

2-1 to 2-4

Administer an assessment task on separating mixtures. Students should work individually without conferring with anyone else.

Preparation

1. Make up a large quantity of a dry mixture. Include large cork chips, sawdust, iron filings, fine sand, salt crystals, and cornstarch powder. Provide one vial for each student in your classes. Students can then pick up a vial and fill it from the bulk mixture. If you want to prepare several different dry mixtures put them into the vials prior to class and label the vials A, B, etc., to indicate which mixture is enclosed.

2. Prepare a liquid mixture containing a highly concentrated solution of dyes or food colorings. Be sure to include substances that will separate into at least three colors- yellow, blue, and red. Provide small test tubes for individuals to use in getting their samples of the liquid mixture.

3. Pre-cut sufficient strips of chromatography paper.

4. Obtain supplies that students will need in making the separations: magnets, sedimentation tubes and stands, funnels, filter paper, sieves, watch glasses, burners, and ring stands.

5. Duplicate individual record sheets.

Procedure

1. Locate the supply of dry mixture in one part of the room, the liquid mixture in another, and the materials students will need to separate the mixtures in a third area.

2. Distribute the record sheets and explain to students that they are to separate each mixture as completely as possible and record their procedures and results on the forms. Tell students that each will select his own equipment from the supply table and work individually without talking. As soon as a student completes work on one mixture he should begin work immediately on the other.

3. Circulate while students are working, but give no assistance. You can check record sheets individually as each student completes his work.

Acceptable Results

Dry Mixture

Step 1. Pass a magnet over the mixture. Iron filings are attracted and thus separated from the mixture.

Step 2. Sieve the rest of mixture and the large cork chips remain in the sieve.

Step 3. Add water to the mixture, shake, and pour into a sedimentation tube. Sawdust floats on top and can be removed. Sand settles to the bottom.

Step 4. Filter the rest of the mixture. Cornstarch does not go through filter paper and is separated.

Step 5. Heat the filtrate and evaporate the water to leave salt crystals.

Liquid Mixture

Step 1. Obtain a strip of chromatography paper.

Step 2. Put a small drop of the liquid mixture on the paper just above one end of the strip.

Step 3. Pour water in a beaker to a depth of 2 cm and suspend the strip so that its bottom edge - but not the dot of dye- touches the water.

Step 4. Wait for several minutes and then observe how many differently colored substances were in the liquid mixture.

DRY MIXTURE

PROCEDURES	DESCRIPTION OF SEPARATED MATERIAL

LIQUID MIXTURE

PROCEDURES	COLORS OBTAINED

2-5

A DESCRIPTION OF MATTER

OBJECTIVES

Process

Identify observations that support an idea or hypothesis. (25)

TEACHING SUGGESTIONS

This activity is designed to help the student summarize, interpret, and apply the concepts developed in the preceding four investigations. He will need the results of his investigations to complete this activity. The statements in the student manual were chosen for one or more of the following reasons

a. To relate conclusions of the four investigations to specific concepts

b. To review methods of separating substances

c. To point out similarities common to all four investigations

d. To differentiate between supported and unsupported statements.

Have several students list their results on the chalkboard. Insist that choices be verified by reference to the actual observations that support each statement.

Expected Results

1. A, B, C, D
2. A, B, C
3. A, D
4. C
5. A
6. B
7. A, B, C, D
8. E

2-6

MAKING SCIENTIFIC MODELS

OBJECTIVES

Processes

1. Construct a model of a simple system.

2. Describe some of the characteristics of a model.

Concept

A model makes possible the study and understanding of something that cannot be directly observed.

REFERENCES

Jacobson, et al. The Atom. pp. 2-4
PSSC. Physics. pp. 160-161
Univ. of Illinois. Universe in Motion. pp. 43-52

TEACHING SUGGESTIONS

Preparation

1. Prepare a sufficient quantity of simple systems to supply one for each student. Use a sealed half-pint milk carton or similar container in which one or more of the following objects has been placed: washer, marble, rectangular block of wood or metal. In selecting materials for the containers, the complexity of the unknown system can be matched to the student's ability.

2. Obtain the following items to be used when introducing the activity:

    a. plastic egg and piece of clay
    b. "super ball"
    c. drinking duck
    d. model of airplane, car, or train

Procedure

1. Before students begin work spend at least part of a period developing background about models. (See references.) Present a physical model of an automobile, train, or plane and ask such questions as, "What does this object represent?", "How do you know it represents that object?", "If this is a good representation of the object, what characteristics should it have?" (Should be scaled, have similar behavior.) What name is generally given to such objects?" (Models)

2. The idea of scientific models may be demonstrated by the actions of one or more of the following:

   a. Random motion of a plastic egg with a sample of clay fixed at different positions (This motion can be changed by varying the location of the clay.)

   b. Action of the "super ball"

   c. Action of the drinking duck (This can be purchased at a novelty store.)

   These actions indicate the existence of situations that are not easily explained. One way to understand such situations might be through the creation of models that exhibit similar behavior.

3. Discuss the materials. Point out a few techniques that might be used to discover the characteristics of the system; e.g., gentle turning should yield more information about the nature of the system than hard shaking. However, do not give any hints as to the structure of the unknown system.

4. Distribute the materials. Emphasize that the containers are to remain sealed.

5. As the students begin work, circulate around the room. Where necessary make suggestions on the manipulation of the system. Allow students ample time to construct and test the models.

6. Have several **students** tell how their systems compare to the unknown system.

Expected Results

A student should be able to construct a model that will duplicate some of the characteristics of the unknown system. It is not necessary that this model be exactly like the unknown system.

Responses to the Interpretation Questions

1. Some similar characteristics might include:

   a. sound
   b. heft
   c. movement (including sliding, rolling, and tumbling)

2. Some models might be:

   a. wind tunnels
   b. solar system
   c. DNA molecules

2-7

HEATING AND COOLING A LIQUID

OBJECTIVES

Process

Describe qualitative and quantitative characteristics of objects and events. (13)

Concept

When a liquid is heated it expands; when a liquid is cooled it contracts. (Later the data from this investigation will be used to develop the concept that particles move apart when heated and move together when cooled.)

TEACHING SUGGESTIONS

Preparation

1. Obtain ice, small flasks, and containers large enough to serve as a waterbath for the flask.
2. Have several capable students or the laboratory aide cut and fire-polish 40 cm lengths of glass tubing and insert them into stoppers that fit the mouths of the small flasks.

Procedure

The purpose of this investigation is to collect information about one of the properties of matter. Simply distribute the materials and have the students perform the investigation. Discuss the observations. At a later time the students will attempt to explain what they have observed.

Expected Results

When the flask of colored liquid is placed in hot water the level of the liquid in the tube should rise; when the flask is placed in the ice water the level of the liquid in the tube should fall.

Responses to Interpretation Questions

1. The level of the colored liquid rose as the flask was heated.
2. The level fell as the flask cooled.
3. When the flask was heated the volume of the liquid increased.
4. When the flask was cooled the volume decreased.

2-8

DYE AND WATER

OBJECTIVES

Process

Describe qualitative characteristics of objects and events. (13)

Concept

When placed in water dye spreads throughout the water. (Later the data from this investigation will be used to develop the concept that particles of matter are in constant motion.)

TEACHING SUGGESTIONS

Preparation

1. Prepare a methylene blue solution by dissolving one gram of methylene blue dye in 250 ml of water.
2. Obtain eyedroppers and large glass containers, such as battery jars or large beakers.

Cautions

1. Caution students to avoid getting dye on themselves or their clothing.
2. Students should make sure that the water in the container is at rest before adding the dye.

Procedure

Distribute the materials and have the students carry out the investigation.

Responses to Interpretation Question

The drops of dye spread throughout the water. The greater the amount of time the greater the spreading of the dye.

Related Activity

This investigation can be performed by students at home:

> Obtain 3 similar clear, colorless containers. Partially fill one container with hot tap water, a second container with water near room temperature, and a third container with cold water. Quickly add 3 drops of ink or food coloring to each container. Observe the three containers every two minutes and record observations in a chart similar to the one used in class.

PAPER TOWELS IN WATER

OBJECTIVES

Process

Describe qualitative characteristics of objects and events. (13)

Concept

When a strip of porous material is placed in a liquid, the liquid may travel up the strip. (Later the data from this investigation will be used to develop the concept that particles exert forces.)

TEACHING SUGGESTIONS

Preparation

1. Cut paper towels in strips that are approximately 2 cm wide and 15 cm long.

Procedure

Distribute materials and have the students carry out the investigation.

Expected Results

In two minutes the water should rise approximately 4 to 5 cm on the paper towel strip.

Related Activity

Vary this investigation at home by using liquids such as vinegar, alcohol, coffee, ketchup, and such substitutes for the paper towel as cloth, writing paper, newspaper, cardboard, and string.

BALL AND RING

OBJECTIVES

Process

Describe qualitative and quantitative observations of objects and events. (13)

Concept

When a solid is heated, its volume increases; when a solid is cooled, its volume decreases. (Later the data from this investigation will be used to develop the concept that particles of matter move apart when heated and move together when cooled.)

TEACHING SUGGESTIONS

Preparation

Obtain alcohol lamps or bunsen burners to be used as heat sources.

Cautions

1. Students should wear goggles when heating with a flame.
2. Students should not reach over the top of the heat source and should not touch the heated ball or ring.
3. Students should not touch the sides of the beaker with the heated metal when cooling the ball or ring in the water.
4. Students should place the ball or ring only on the asbestos pad, not on the desk.

Procedure

Discuss cautions before distributing the materials for this investigation. Circulate throughout the room to make sure all groups are adhering to the cautions.

Expected Results

1. At room temperature the ball should pass through the ring.

2. When the ball is heated it should not pass through the ring.

3. When the ring is heated the ball should pass through the ring.

4. When both the ring and ball are heated the ball should pass through the ring.

Responses to Interpretation Questions

1. There is no size change in either the ball or ring.

2. When the ball is heated it gets larger.

3. When the ring is heated it gets larger.

4. When the ball and ring are both heated they both get larger.

GLASS SLIDES AND WATER

OBJECTIVES

Process

Describe qualitative observations of objects and events. (13)

Concept

When water is placed between two glass slides, the slides stick together. (Later the data from this investigation will be used to develop the concept that there are attractive forces between particles.)

TEACHING SUGGESTIONS

Caution

Make sure the glass slides have no sharp edges.

Procedure

Distribute the materials and have the students carry out the investigation.

Expected Results

Dry glass surfaces can be separated with little difficulty. Wet glass surfaces are extremely difficult to separate.

Response to Interpretation Question

The glass slides were more difficult to separate when they were wet.

2-12

A PAPER CLIP AND WATER

OBJECTIVES

Process

Describe qualitative observations of objects and events. (13)

Concept

Under some circumstances objects made of substances that ordinarily sink can be made to rest on the surface of water. (Later the data from this investigation will be used to develop the concept that surface tension is an example of the attractive forces between particles.)

TEACHING SUGGESTIONS

Procedure

1. Distribute the materials and have the students carry out the investigation.

2. In Procedure Item 4 Drawing C approximates the cross-sectional view of the paper clip on water.

3. If students wish to call the phenomenon observed in this investigation "surface tension," they may do so, but do not attempt an explanation at this time. The explanation of this phenomenon will come during the model-building sequence.

Related Activity

Do this investigation at home using liquids such as vinegar, alcohol, or coffee and water containing various amount of soap.

2-13

THE UNKNOWN IN A BAG

OBJECTIVES

Process

Describe qualitative observatiins of objects and events. (13)

Concept

Some substances can be identified at a distance by their odors. (Later, the data from this investigation will be used to develop the concept that particles move.)

TEACHING SUGGESTIONS

Preparation

1. Quarter several onions. Place an onion quarter in each paper bag. Odor will be most apparent if the onions are prepared at least an hour before being used.
2. Tie the necks of the bags tightly enough so that it will be impossible for students to see the contents.
3. Moth balls or perfume can be substituted for the onion.

Procedure

1. Distribute the paper bags and have the students carry out the investigation.
2. Make sure that the students do not open the bags.

Expected Results

The student should recognize that an odor is given off by the contents of the bag.

Response to Interpretation Question

The odor of the object would be most helpful to identify it.

ICE CUBES

OBJECTIVES

Process

Describe qualitative observations of events. (13)

Concepts

1. When heated, an ice cube first changes to a liquid; then this liquid disappears.

2. Later, the students will use this investigation to develop the concept that heat affects particles.

TEACHING SUGGESTIONS

Preparation

1. Use ice cubes of approximately the same size as those made in a home refrigerator.

2. Use alcohol lamps as a heat source.

Cautions

1. Remind students to wear goggles at all times when using a flame.

2. Tell students not to tilt the alcohol lamps because of the possibility of fire.

Procedure

1. Distribute the materials for this investigation. The results are most easily observed if no more than three students work in each group.

2. As the students carry out this investigation circulate through the class in order to determine that students are using the alcohol lamps properly.

Expected Results

The ice should change into water when heated and the water formed from the ice should change into vapor. However, vapor does not form until all the ice has been changed into water. The students probably will not notice this and it need sot be pointed out at this time.

2-15

SWIRLING SMOKE

OBJECTIVES

Process

Describe qualitative characteristics of events. (13)

Concept

When a gas from hydrochloric acid and a gas from ammonium hydroxide solution come in contact there is evidence of a change. (Later the data from this investigation will be used to develop the concepts that the particles in a gas move and that there are spaces between particles of a gas.)

TEACHING SUGGESTIONS

Preparation

Assemble the equipment and reagents prior to the demonstration. Two pint jars may be used instead of beakers. The jars have smooth tops and one will sit on top of the other without being held in place.

Caution

Handle acid and ammonium hydroxide with extreme care. DO NOT MIX MORE THAN ONE OR TWO DROPS OF CONCENTRATED HYDROCHLORIC ACID WITH CONCENTRATED AMMONIUM HYDROXIDE. Larger quantities will react violently.

Procedure

Perform this activity as a teacher demonstration.

Responses to Interpretation Questions

1. The drop of acid reacts with the drop of ammonium hydroxide to form a white cloud.

2. When the glass plate is removed a white cloud of swirling "smoke" appears.

3. The appearance of the white cloud is similar in both demonstrations.

4. In the test tube the chemicals were in direct contact. In the beakers the chemicals were not in direct contact. The cloud in the beakers was larger than in the test tube.

2-16

OBSERVING FILTER PAPER

OBJECTIVES

Process

Describe qualitative observations of events. (13)

Concept

It is possible to observe by indirect means the movement of a substance from one place to another. (Later the data from this investigation will be used to develop the concept that particles move.)

TEACHING SUGGESTIONS

Preparation

1. Prepare a solution of one gram of phenolphthalein in 100 ml of alcohol.

2. If sufficient reagent bottles cannot be obtained, use stoppered test tubes and a stand.

Cautions

1. Have students use forceps when moving the saturated filter paper.

2. Tell the students to avoid contact with ammonium hydroxide solution. Vapors from this solution should also be avoided.

Procedure

Distribute the materials and have the students carry out the investigation.

Expected Results

1. Ammonium hydroxide should cause the phenolphthalein solution to turn pink when the two come in direct contact.

2. The soaked filter paper turns pink when it is suspended over the ammonium hydroxide solution.

Responses to Interpretation Questions

Yes. The phenolphthalein turned pink when placed over the ammonium hydroxide. Therefore, the two substances must have come in contact in some way.

2-17

ALCOHOL AND WATER

OBJECTIVES

Process

Describe qualitative and quantitative characteristics of events. (13)

Concept

When equal volumes of water and alcohol are mixed, their combined volume is less than the sum of their separate volumes. (Later the data from this experiment will be used to develop the concept that there are spaces between particles of matter.)

TEACHING SUGGESTIONS

Preparation

If enough methyl alcohol is not available for students to work in groups of three, the investigation may be done as a teacher demonstration, using 100 ml each of alcohol and water.

Caution

Tell students to avoid any oral contact with the methly alcohol.

Procedures

1. Before allowing students to begin this investigation, review the proper way to read a graduated cylinder.

2. Demonstrate a technique to increase the accuracy of volume measurements by using an eyedropper to add liquid drop by drop as the desired volume is approached.

3. Circulate while the students are working but do nothing to suggest the nature of the expected results.

Expected Results

When equal volumes of water are mixed, the total volume is the sum of their separate volumes. When equal volumes of alcohol are mixed, the total volume is the sum of their separate volumes. However, when equal volumes of water and alcohol are mixed the total volume is less than the sum of their separate volumes. The 25 ml of alcohol mixed with 25 ml of water will have a combined volume of 48 to 49 ml.

Responses to Interpretation Questions

1. Mixing the alcohol with the water yields an unexpected result.

2. When alcohol is mixed with water, the total volume is less than the sum of the separate volumes.

A SET OF GLASS TUBES

OBJECTIVES

Process

Describe qualitative observations of events. (13)

Concept

The levels of liquids in capillary tubes vary according to the kinds of liquid and according to the diameters of the tubes. (Later the data from this investigation will be used to develop the concept that particles exert forces.)

TEACHING SUGGESTIONS

Preparation

Prepare six to eight sets of equipment for the class. Glass tubing with the following inside diameters is generally available in schools: 0.25 to 0.75 mm; 0.75 to 1.25 mm; 1.25 to 1.75 mm; 2.4 mm; 3.4 mm; 5.0 mm. Cut tubing into 10 cm lengths. Each student group should be given a set of 10 cm lengths of tubing of varying inner diameters.

Caution

Mercury is dangerous and should be handled with the greatest care. For each group use just enough mercury to cover the bottom of the beaker to a depth of approximately 5 mm. Caution students to avoid putting their hands or personal objects in the mercury. If any is spilled, have the area cleaned quickly and carefully. Work in a well ventilated room.

Procedures

1. Have students obtain their sets of materials from stations located around the room. The teacher should pour the mercury into the beakers and collect it at the end of the investigation.
2. Emphasize that the work with mercury is to be done first. This eliminates the need for drying the tubing between the steps of the procedure. The students should be able to carry out the work with water on their own.

3. During the discussion it will probably be necessary to develop the meaning of the following terms: meniscus, concave, convex, and bore.

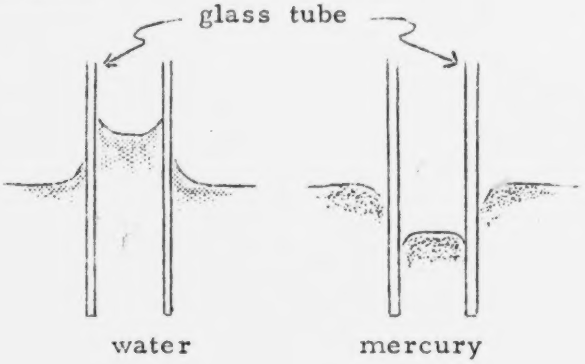
Expected Results

The mercury in the capillary tube should be at a lower level than the surrounding mercury and should have a convex meniscus. The water in the capillary tube should be above the surrounding water and it should have a concave meniscus. The smaller the bore of the tube, the higher the water rises and the lower the mercury is depressed.

Responses to Interpretation Questions

1. Students will probably see little, if any similarity of behavior.

2. In each tube the water rose and had a concave meniscus while the mercury was depressed and had a convex meniscus.



Tubes should have same diameter.

3. The smaller the bore, the higher the water rose.

4. The smaller the bore, the lower the mercury was depressed.

2-19

AN UNUSUAL BALLOON

OBJECTIVES

Process

Describe qualitative observations of events. (13)

Concept

When a partially filled balloon is placed in a vacuum, the balloon expands. Later the data from this investigation will be used to develop the concept that particles move and that there are spaces between the particles of a gas.

TEACHING SUGGESTIONS

Caution

The sealing compound often makes it difficult to remove the bell jar from the vacuum pump platform. A twisting or sliding motion works better than direct pulling.

Procedure

Most schools have only one vacuum pump, so this investigation should be carried out as a demonstration. Follow the procedures listed in the Student Manual.

Expected Results

As the bell jar is evacuated, the balloon increases in size. When air is allowed to re-enter the bell jar, the balloon returns to its original size.

Responses to Interpretation Questions

1. The balloon got larger because the air inside it expands when a vacuum was formed in the bell jar.

2. The balloon got smaller when air went back into the bell jar because the air outside the balloon had a greater pressure than the air in the expanded balloon and was thus able to push the balloon back to its original size.

2-20

CLASSIFYING OBSERVATIONS OF MATTER

OBJECTIVES

Process

Classify events by similarities of behavior. (15a)

REFERENCE

Overview to Phase Two

TEACHING SUGGESTIONS

1. Emphasize that the groupings of observations are to based upon the behavior that the matter exhibited. Divide the class into working groups of 4 or 5 students and have them begin classifying the investigations.

2. As the students are working, circulate to determine how they are progressing. Some groups may have difficulty but do not be hasty in offering suggestions. However, if a group continues to have difficulty it may be necessary to point out a similarity of behavior between two investigations. For example, pose the question, "Do you see any similarity of behavior between what happened to the dye in the water in 2-8 and the way in which the filter paper was changed in 2-16?" If students cannot answer the question it may be helpful to suggest that the dye moved through the water and the ammonium hydroxide seemed to move through the air. Movement was a behavior of the dye and the ammonium hydroxide. Hopefully, students will be able to continue by looking for other investigations exhibiting similar behavior.

3. When all groups have completed work, have several classification schemes presented to the class. Lead a class discussion concerning the merits and limitations of each of the classification schemes. Guide the discussion so that the class recognizes and accepts a classification scheme that embodies the following groupings:

Group 1. Movement of Substances

Dye and Water (2-8)
The Unknown in a Bag (2-13)
Swirling Smoke (2-15)
Observing Filter Paper (2-16)

Group 2. Effects of Heat

Heating and Cooling a Liquid (2-7)
Ball and Ring (2-10)
Ice Cubes (2-14)

Group 3. Forces in Matter

Paper Towel in Water (2-9)
Glass Slides and Water (2-11)
A Paper Clip and Water (2-12)
A Set of Glass Tubes (2-18)

Group 4. Changing Volumes

Alcohol and Water (2-17)
An Unusual Balloon (2-19)

2-21

FROM MANY TO ONE

OBJECTIVES

Processes

1. Construct one or more ideas from a set of observations. (24)
2. Distinguish whether or not an idea is supported. (26)

Concepts

1. Many physical properties of matter can be explained by a particle model.
2. The behavior of matter indicates that there are spaces between the particles.
3. The behavior of matter indicates that particles move.
4. The behavior of matter idicates that particles move farther apart when heated and move closer together when cooled.
5. The behavior of matter indicates that particles exert forces.

TEACHING SUGGESTIONS

Procedure

1. Do not begin this activity until students have completed 2-20.
2. If you feel that students need help, give them a start by posing a hypothetical situation, as follows:

   > Suppose that several investigations show that matter occupies a greater amount of space when heated and a lesser amount when cooled. You can explain this by assuming that matter is made of microscopic animate objects or "Little People." When these "Little People" have heat applied to them, they attempt to get away from the heat and from one another. This could account for the expansion. When matter is cooled, these "Little People" move closer together in order to keep warm.

Some students may want to accept this hypothesis; most will feel that it is ridiculous. Have the students discuss the merits and drawbacks of such a hypothesis, and then let them begin work on their own set of hypotheses. It is impossible to say how long it will take to complete this work. Faster students may complete a set of hypotheses in a period or less, while other classes may require more time to accomplish this. Allow for as much discussion within and between groups as is possible. Except for groups that indicate a complete lack of ideas about what to do and how to do it, allow students to work completely on their own.

3. When the students have completed working, allow each group to present its set of hypotheses to the class. Discuss the merits and limitation of each set of hypotheses. Have the class decide upon one set of hypotheses that best explains the behavior of matter and tell the students to record the list as Item 1 of the Interpretation.

   In most cases little guidance is likely to be required to bring students to see that a particle hypothesis best explains the highly selected observations. At the completion of this investigation students should henceforth refer to the particles as molecules.

Responses to Interpretation Questions

1. The response to the first interpretation question should include all of the investigations that were used to observe the behavior of matter. One acceptable list of hypotheses and supporting investigations is:

   a. All matter is composed of very small particles. (2-7 to 2-19)
   b. There are spaces between molecules. (2-17, 2-19)
   c. Particles move. (2-8, 2-13, 2-15, 2-16)
   d. Particles move farther apart when heated; they move closer together when cooled. (2-7, 2-10, 2-14)
   e. Particles exert forces. (2-9, 2-11, 2-12, 2-18)

2. There should be no investigation listed for the response to this question.

Assessment Task

Answer each of the questions below by selecting one or more of the hypotheses listed below. Show your selections by writing the letters of the hypotheses in the spaces provided in front of the questions.

a. All matter is made of very small particles.

b. There are spaces between particles.

c. Particles move.

d. Particles move farther apart when heated; they move closer together when cooled.

e. Particles exert forces.

_____ 1. Which of the hypotheses is supported by the observation that a piece of steel when placed in a candle flame changes volume from 12.2 cc to 12.4 cc?

_____ 2. Which of the hypotheses is supported by the observation that a solid chunk of dry ice, when completely changed to gas, takes up a much larger space?

_____ 3. One gallon of a green liquid disinfectant is poured into a large still swimming pool and observed to spread throughout the entire pool. Which of the hypotheses is supported by this observation?

_____ 4. Which of the hypotheses is supported by the observation that water dripping from a faucet generally takes a nearly spherical shape?

The most acceptable responses for the questions are:

1. d
2. d
3. b, c
4. e

However, for Item 1, b also has some relevance; likewise for Item 2, b and c are involved.

2-22

EXTENDING THE MODEL OF MATTER

From the last series of investigations students obtained information that allowed them to construct a particle model of matter. In the next series they will decompose several compounds into simpler substances, and from their observations try to extend their model of matter to include the idea that some particles are composed of still smaller particles.

In 2-23 to 2-26 the objective is to distinguish elements and compounds from each other through observing that some materials can be decomposed into simpler substances and others cannot be decomposed. In 2-23, 2-25, and 2-26 students work with a simple substance, oxygen, and observe its unique set of properties. In 2-24 and 2-25 they deal with a second simple substance, hydrogen, and see its set of properties. In 2-28 the students classify the substances they have been experimenting with into those that can be broken down and those that cannot. The terms, compound and element, should not be introduced until this time. Elements and compounds, other than those used in the investigations, may be introduced and identified at the discretion of the teacher. 2-27 is an assessment task.

The obvious question, "Are elements really the smallest bits of matter?" leads into the final group of investigations in Phase Two, 2-29 to 2-34, designed to help students develop an atomic model of matter.

HEATING AN ORANGE-RED POWDER

OBJECTIVES

Processes

1. Distinguish among solids, liquids, and gases. (15)
2. Describe in writing the decomposition of mercuric oxide. (13)

Concepts

1. A substance may be decomposed into two substances different from the original substance and from each other.
2. Gas A (Oxygen) is colorless, odorless, tasteless, heavier than air, and supports combustion.

REFERENCES

Brandwein, et al. The World of Matter-Energy. pp. 26-27

Joseph, et al. A Sourcebook for the Physical Sciences. pp. 129-136

TEACHING SUGGESTIONS

Preparation

This investigation is to be performed as a teacher demonstration. Before starting, read Page 129 in A Sourcebook for the Physical Sciences. Be sure to test the procedures prior to the class period.

Cautions

1. Consult the Baltimore County Laboratory Safety Manual for specific precautions about handling mercuric oxide and mercury.
2. Have students wear goggles throughout the demonstration.
3. Point out to students that one should always be certain that the tubing portion of the system is clear of all obstructions before heating.

4. When you finish heating, remove the rubber tubing from the water. This prevents the water from going back into the hot test tube.

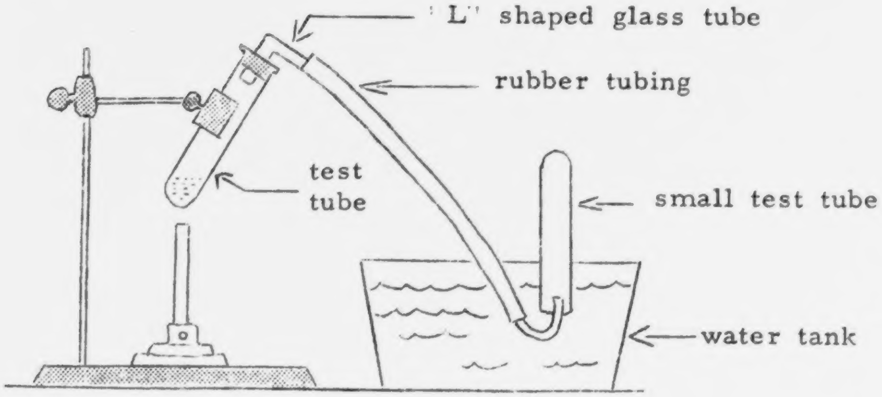
Procedure

1. Begin by having the students read "Extending the Model of Matter" in the Student Manual.

2. Before performing the demonstration, go over the student investigation sheet with the class. Point out to the students that they will be filling in the record chart on Page 48 of the Student Manual as they go through this next series of investigations.

3. Perform the demonstration, using the following materials:

mercuric oxide, 5 g
test tubes, 15 mm x 150 mm, 5
stopper, one-hole, #1
glass tube, L-shaped
rubber tubing
goggles
rubber stoppers, solid, #1, 4
water tank
wooden splints
bunsen burner
ring stand
burette clamp



a. Put the mercuric oxide into one of the test tubes. Label the other tubes 1, 2, 3, and 4.

b. Put a glowing splint into the top of the tube with the mercuric oxide and have the students observe what happens. No change will occur or the splint may go out.

c. Fill the other test tubes with water and invert them in the water tank. Since this will be the first time the students have observed a gas being collected, explain gas collection techniques.

d. Put the end of the delivery tube into the first test tube and collect the gas produced by heating the mercuric oxide. After the gas is collected stopper the tube with a rubber stopper. Then collect a second, third, and fourth tube of the gas and stopper them also. Test the contents of the first tube with a glowing splint. The splint will merely continue to glow since the gas collected is mostly air that was trapped in the large tube. Place the glowing splint in the second tube. The glowing splint should burst into flame due to the higher concentration of oxygen. Remove the stoppers of the remaining two tubes. Invert one tube and leave the other tube upright. After 10 to 20 seconds test each tube with the glowing splint. In the upright tube the splint should burst into flame; in the inverted tube the splint will merely continue to glow. Oxygen is heavier than air and remains in the upright tube but flows out of the inverted tube.

e. Have the students observe the remaining orange-red powder 10 minutes after the heating has been stopped.

5. During discussion of the demonstration do not name the substances, nor use the terms element or compound These terms will be developed in a future investigation. However, students should see that two new types of particles are present, each with its own distinctly different characteristics. One type of particle could be described as a silvery liquid, the other as a colorless gas that supports combustion. The

gas may be referred to as "Gas A," since a second gas will be encountered in 2-24.

Expected Results

Name of Investigation	Initial Substances	Final Substances
Heating an Orange-Red Powder	An orange-red powder	A silvery liquid, a colorless gas, and a dark powder

Responses to Interpretation Questions

1. The orange-red powder turned black when heated. A silvery substance formed on the sides of the large test tube. Bubbles formed in the small test tube.

2. The gas forced the water out of the tube.

3. The orange-red powder was being changed into other substances.

4. The silvery substance came from the orange-red powder.

5. Trapped air from the large test tube filled the first tube, some other gas from the orange-red powder filled the second tube.

6. The gas is heavier than air.

7. The particles went back together to form the orange-red powder again.

8. The orange-red powder separated into two different kinds of particles. The particles moved apart when heated. The particles exerted a force on the water.

LIQUID X AND ZINC

OBJECTIVES

Processes

1. Construct a laboratory set-up from a diagram.

2. Demonstrate a procedure for collecting a gas by displacement of water.

3. Describe qualitative characteristics of objects and events. (13)

Concepts

1. Some gases are lighter than air.

2. Some gases are combustible.

REFERENCE

Joseph, et al. A Sourcebook for the Physical Sciences. p. 143

TEACHING SUGGESTIONS

Preparation

1. Prepare enough glass bends for one to each group. Make sure that the ends of the glass bends are not closed. Insert the bends into stoppers before class time.

2. Prepare Liquid X by mixing 15 ml of concentrated sulfuric acid with 85 ml of water. CAUTION: POUR ACID INTO WATER SLOWLY, STIRRING CONSTANTLY. This will give an approximately 6N sulfuric acid solution sufficient in quantity for four teams (25 ml per group).

3. Prepare the generating test tubes before class time by pouring 20-25 ml of Liquid X into each tube. Have these test tubes available so that students can pick them up when they are ready to assemble their apparatus.

4. The pegboard base and metal clips can be used as an optional set-up for the ring stand and clamp.

Cautions

1. In preparing Liquid X, pour ACID into WATER.

2. Glycerine must be used on glass tubing before insertion into the stopper.

3. Check that students do not bend the rubber tubing in such a way that the flow of gas to the collecting tube is cut off.

4. Goggles must be used from the time the students pick up the test tube of Liquid X until they complete cleaning up the equipment.

5. Do not use flasks to generate or collect the gas.

Procedure

1. In this investigation students work with strong acids and with gases for the first time. In a pre-laboratory discussion, build a model laboratory set-up for the students. During this construction emphasize Cautions 2, 3, and 4. Also review the gas collecting and identifying techniques. Remind the students to make sure that the generating test tube is secure so that Liquid X does not spill at any time.

2. Distribute the equipment and allow students time to complete the investigation. They should have no difficulty in collecting several tubes of gas. The upright tube that has the rubber stopper removed for sixty seconds should not give a reaction to the burning splint. If the interval is shorter, a small reaction may occur. The inverted tube should produce a small "pop" from ignition of the hydrogen gas, which may be called "Gas B."

3. When students have completed the procedure, have them clean up before beginning to answer the interpretation questions, which may be completed at home for discussion the following day.

4. Begin the next class session by asking students if they have questions or comments pertaining to the equipment and materials or to the procedures used to collect and test the gas. Then have several students read their responses to the interpretation questions and have the class react to them. Give students time to make changes or add additional comments in their manuals. Have students place the data from this investigation in the proper columns on their record chart.

Responses to Interpretation Questions

1. From the action of the liquid, the zinc appears to be dissolving. Small bubbles appear on the zinc and rise to the surface of the liquid.

2. The water is being forced out of the small test tube by pressure of the gas bubbles coming from the end of the rubber tubing.

3. The substance in the small test tube is lighter than air. The evidence to support this answer is: a) There is no reaction from the burning splint when testing the upright tube; the gas floats away in the upright tube. b) The gas cannot escape from the inverted tube; the burning splint causes a small pop in the inverted tube as the gas explodes.

4. The substances used at the beginning of the experiment are a solid piece of zinc metal and a clear liquid. The substance that you get as a result of the reaction is a gas that is lighter than air. This gas is explosive.

2-25

ELECTROLYSIS

OBJECTIVES

Process

Distinguish between gases on the basis of physical properties.

Concept

Liquid Y can be decomposed into two gases by passing an electrical current through it.

REFERENCES

Haber-Schaim, Uri. Introductory Physical Science, Teacher's Guide. pp. 148-149

TEACHING SUGGESTIONS

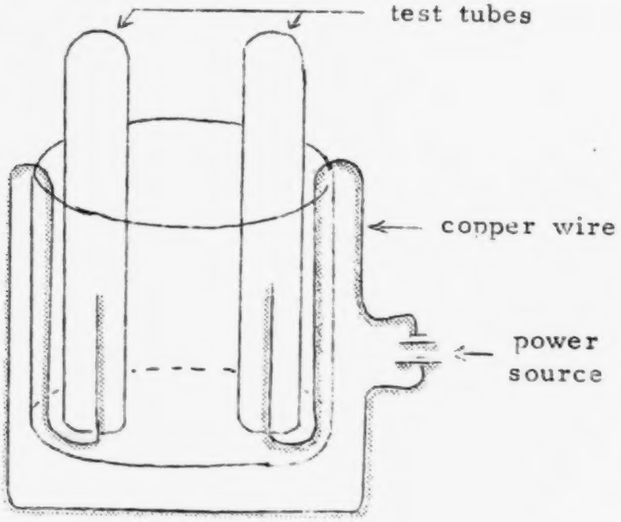
Preparation

This activity is to be done as a teacher demonstration. It is designed to show that Liquid Y (water) can be decomposed into smaller particles.

1. Prepare a very dilute sulfuric acid solution to be used as the electrolyte. This is accomplished by adding 1 ml of concentrated acid to 100 ml of water.
2. Test the effectiveness of the solution with the electrolysis apparatus. The more voltage used, the faster the reaction will take place. A twelve-volt source should prove satisfactory.
3. Strip the wire ends that are in the solution to improve conduction.

4. Two sets of the following materials will be needed:

test tubes, 15 mm x 100 mm, 2
copper wire, #14, plastic
covered, 1 m
beaker, 400 ml
power source
wood splints



Procedure

1. One set of apparatus should be set up before the class enters the room and another should be set up during class. This allows the students to see what occurs in the demonstration after a period of time as well as at the very beginning. Have the students describe the set-up and what they see occurring.

2. Use the set-up that was operating before the students entered the room to test the two gases. Leave the demonstration set-up, constructed during class time, in operating condition so that it may be used with the next class.

3. Discuss the interpretation questions. It is not necessary to discuss charges or reactions at this time since the purpose of this activity is merely to show that water can be broken into smaller particles.

Expected Results

1. Bubbles appear.

2. Water moves down the tubes as bubbles are formed at the wires.

3. Yes, the levels of Liquid Y in the test tubes change. Gas occupies the spaces above the levels of the liquid.

4. One is about twice the other.

5. In the tube with the smaller amount of gas, the glowing splint burns brighter. In the other tube the burning splint produces a "pop" and the glowing splint stops glowing.

Responses to Interpretation Questions

1. From Liquid Y.

2. Yes, there are two substances produced, as evidenced by the different reactions to the splints.

BUBBLING WATERS

OBJECTIVES

Processes

1. Construct a laboratory set-up from a diagram.
2. Describe qualitative characteristics of objects and events. (13)

REFERENCE

Joseph, et al. A Sourcebook for the Physical Sciences.
pp. 134-136

TEACHING SUGGESTIONS

Preparation

The hydrogen peroxide solution (Liquid Z) should be 3 per cent (the hydrogen perioxide obtainable from the drug store). If your laboratory has 30 per cent H_2O_2, add 1 part H_2O_2 to 10 parts H_2O.

Cautions

1. Have the students wear goggles throughout the entire investigation.
2. Tell the students to be certain that the tubing portion of the system is clear of all obstructions.

Procedure

In this investigation Liquid Z (H_2O_2) is broken down to produce water and oxygen. The MnO_2 is a catalyst. The students collect and test this gas by methods previously used or demonstrated.

1. Discuss the set-up, and the gas collecting techniques. Because of the quickness of the reaction, emphasize the need for speed, organization, and efficiency. Point out that the action will probably take no more than 2 minutes.

2. After reviewing the cautions, distribute the materials and have students complete the investigation.

3. Have students clean and return the equipment to the storage area before beginning to answer the interpretation questions, which may be completed at home.

4. The following day have a student review the procedures and apparatus used in the investigation. Discuss the results of the investigation and the interpretation questions.

Expected Results

If the students work quickly and efficiently they should be able to collect 4 test tubes of gas. When tested the gas should cause a glowing splint to burn brighter. In describing the gas, the students should note that it is colorless and odorless. They will probably not mention that it is tasteless and heavier than air; these points should be brought out in the discussion.

Responses to Interpretation Questions

1. A gas was given off and there were bubbles in the test tube.

2. The water was forced out.

3. The water acted the way it did because gas exerted a force.

4. The liquid began to bubble. Water was forced out of the collecting tube.

5. Observations of this investigation indicate that particles of Liquid Z can be broken down. Some students will probably say MnO_2 broke down. If this occurs, explain the function of MnO_2 as a catalyst.

2-27

GAS FROM LIQUID W AND A RIBBON

This is an assessment task that checks the processes and skills developed during 2-23 through 2-26. Since only a few students can be evaluated at a time, an alternate activity must be provided for the rest of the class. While one group is being assessed, give the other students current science reading, paper and pencil tests, or allow them to begin 2-28.

TEACHING SUGGESTIONS

Preparation

Prepare Liquid W by adding 100 ml of fresh concentrated hydrochloric acid to 400 ml of water. Place the liquid in the generating tubes before class begins.

Procedure

1. Set up two to four stations at the back of the room and call on groups to perform the assessment task while the rest of the class continues with the preassigned activity. Indicate the degree of accomplishment by checking the appropriate column of the evaluation chart on the next page. With the assistance of a laboratory aide, you should be able to evaluate during one period the performance of students in a class of average size.

2. Tell the students that they will not receive any help during the performance of the assessment task unless there is danger involved due to the violation of a safety rule.

Acceptable Responses

1. The student will demonstrate his ability to set up the apparatus and collect a gas by water displacement. After filling each small test tube with water, the student will invert each one beneath the surface of the water in the tank in such a position that the water remains in the collecting tube.

2. The student will slide the magnesium ribbon into the large tube (which should already contain Liquid W) and carefully insert the stopper with the glass bend and rubber tubing.

The equipment set-up is the same as in 2-24. The student will discard the first test tube of gas collected. The second and third test tubes of gas will be stoppered and used for testing.

3. The student will invert one tube and hold the other in an upright position. He will then remove the solid stoppers from each of the two test tubes. After a short interval of time the student will use either a glowing or a burning splint to test the gas. The student will not get a reaction with the glowing splint. The burning splint will produce a small "pop" when held near the mouth of the inverted tube. This "pop" will indicate to the student that the gas was lighter in mass than the air.

4. Also, from this procedure the student will distinguish whether the gas is explosive or whether it supports combustion.

EVALUATION CHART

Student Performance	Yes	No
1. Handles unknown liquid carefully.		
2. Constructs equipment set-up to collect gas by water displacement.		
3. Discards the first test tube of collected gas.		
4. Inverts one test tube of gas and keeps the other upright in order to determine the density of the gas relative to the air.		
5. Before performing flame test waits for a short interval of time after removing stoppers from test tubes.		
6. Determines that gas is explosive.		
7. Shares and accepts ideas from teammates on proper set-up of apparatus and procedures.		

This evaluation chart is simply a means of helping you to record easily the data pertinent to the evaluation of teams, groups, or individuals. It may be reproduced in quantity.

DISTINGUISHING AMONG SUBSTANCES

OBJECTIVES

Process

Distinguish between a compound and an element on the basis of observable properties and behavior. (15)

Concepts

1. Compounds can be chemically broken down into simpler substances.

2. Elements cannot be chemically broken down into simpler substances.

TEACHING SUGGESTIONS

Preparation

Obtain several examples of compounds and elements from the science supply room.

Procedure

1. Have the students place on their desks the record sheet from 2-22. Then have them read the procedure for this investigation. Make sure that they understand how to complete the charts on Page 64. As the students work, circulate and check their answers.

2. After students complete the activity, hold a class discussion. Point out that some of the final substances (zinc sulfate, magnesium sulfate) are not listed. It is not necessary to mention either compound by name in this discussion since we are not interested in a chemical analysis of the reaction. If the students suggest that the magnesium breaks down, explain that magnesium is already in its simplest form. In the "Bubbling Waters" investigation the students may think that the black powder (manganese dioxide) should also be considered a substance that broke down. Tell the students that the black powder helped to cause the results they observed in this experiment. It did not break down, however, and should not be considered for classification at this time.

3. After completing the discussion, show the students samples of compounds and elements from the science supply room.

EXPECTED RESULTS

Investigation	Initial Substance	Final Substance
Heating an Orange-Red Powder	mercuric oxide	mercury oxygen
Liquid X and Zinc	zinc sulfuric acid	hydrogen
Electrolysis	water	hydrogen oxygen
Bubbling Waters	hydrogen peroxide	oxygen
Gas from Liquid W and a Ribbon	magnesium hydrochloric acid	hydrogen

Substances That Were Broken Down	Substances That Were Not Broken Down
mercuric oxide	mercury
sulfuric acid	oxygen
water	hydrogen
hydrogen peroxide	zinc
hydrochloric acid	magnesium

Responses to Interpretation Questions

1. The substances that were broken down were made of more than one kind of particle.

2. All the substances that were not broken down were made of one kind of particle except the black powder (manganese dioxide), which was a catalyst.

RUBBING SUBSTANCES TOGETHER

OBJECTIVES

Processes

1. Describe qualitative characteristics of events. (13)
2. Construct an idea from a set of observations. (24)

Concepts

1. Particles can be removed from matter by rubbing.
2. Matter is electrical in nature.

TEACHING SUGGESTIONS

Preparation

Obtain the PSSC Electrostatics Kit. Coat the white styrofoam balls with a colloidal suspension of graphite in alcohol or with India ink. Attach the nylon filament string to the styrofoam balls.

Cautions

The success of this experiment depends upon the relative humidity in the room. If it is about 50 per cent or less, this experiment will work well, but if it is about 80 per cent or more, charges leak off. To reduce leakage in high humidity, store the materials in a large box heated by an electric bulb and remove them just before use.

Procedure

1. Issue materials to the students. If possible allow the students to work in groups of three. As the students carry out the procedure, circulate around the classroom making certain that the students touch the balls with dry hands.
2. Begin the discussion by having students read their responses to Interpretation Item 1. Make sure that they get the idea that the ball and the strips behave differently before and after rubbing. Accept all answers for the second question;

however insist that students support their answers with evidence. Someone may suggest that particles are being rubbed off. If not, you will have to tell the students that particles were removed in the process of rubbing the strips. Then ask, "How are the particles rubbed off?" Some students may say that the cloths rubbed off the particles from the strips while others might say that the strips took particles from the cloths. Accept either statement because, at this time, the students have no evidence to support the fact that one is more accurate than the other. Point out that this investigation illustrates that matter is electrical in nature. Do not mention the identity of the particles at this time. This investigation should establish that there are very small particles that cannot be seen but these particles can nevertheless be detected.

Related Activities

a. Lay a sheet of paper on a table and rub it with the long side of a pencil. Explain what happens when the paper is picked up.

b. Cut up tiny pieces of paper. Rub a comb briskly against a woolen cloth. Describe what happens when the rubbed comb is brought in contact with the pieces of paper.

ELECTRICITY FROM CHEMICAL SUBSTANCES

OBJECTIVES

Process

Construct an idea from a set of observations. (24)

Concepts

1. Matter is electrical in nature.
2. Electricity may be observed from compounds and elements.
3. Atoms are made of smaller particles.

REFERENCE

Joseph, et al. A Sourcebook for the Physical Sciences. p. 257

TEACHING SUGGESTIONS

Preparation

Prepare dilute sulfuric acid by carefully adding 100 ml of concentrated acid to 900 ml of water. Each cell requires about 250 ml of dilute acid.

Cautions

1. SULFURIC ACID IS DANGEROUS!
2. Goggles must be worn throughout the work.
3. Spilled acid must be cleaned up immediately with liberal use of water.
4. Acid on clothing will result in holes unless the clothing is promptly washed.

Procedure

1. Explain cautions to students and circulate while they work.

2. Base the post-laboratory discussion on the interpreation questions. Develop the following ideas:

   a. A flow of electricity was produced from the chemical substances.

   b. Matter is affected by electricity (as in electrolysis).

   c. Matter can produce an electrical current.

   d. There are smaller particles than atoms and molecules.

Expected Results

The properly assembled cell will produce an electric current of low voltage.

Responses to Interpretation Questions

1. The source of the "particles of electricity" is one or more of the chemical substances involved in the set-up.

2. The source of "electrical particles" in electrolysis was a battery or power pack.

3. Students may recognize that the "electrical particles" are of the same type as those "rubbed" off in 2-29.

2-31

A BIG MODEL OF A SMALL SHOOTING RANGE

OBJECTIVES

Processes

1. Construct a statement that describes a set of data. (22)

2. Construct one or more ideas from a set of observations. (24)

3. Order a set of ideas from least to most probable. (27)

4. Distinguish whether or not an idea is supported by evidence. (26)

Concept

An atom has a dense inner mass surrounded by mostly empty space.

REFERENCE

Brandwein. Matter, Its Forms and Changes. pp. 40-41

TEACHING SUGGESTIONS

Procedure

1. Before the students obtain their materials show them how to set up the apparatus. Tell them that they are to move the shooter to different positions in front of the model. Explain that this is done so that the bullet (marble) goes through the model in different directions and from different starting points and that this is the only way in which they will be able to determine the internal structure of the model.

2. Have students obtain the materials but ask them not to look at the bottom of the model or examine it in any way. The model is to be a "black box" for the students. If the students have prior knowledge about the structure of the model, the analogy between it and the model that Rutherford created loses much of its effectiveness.

3. Have the students complete the procedure but not the interpretation questions. While the students are working circulate and observe what they are doing and how they are doing it. If any of the trials result in the bullet (marble) not coming through the model, have the students notify you and you remove the marble. In this way the model will remain a "black box" for the students.

4. Ask each group to record its summed results on the chalkboard so that the class as a whole has a large amount of data to use rather than the limited sample obtained by each group.

5. Have students complete the interpretation questions and then have a thorough discussion, comparing Rutherford's model and their own. Be sure to point out that both of these models are many times larger than the reality they simulate.

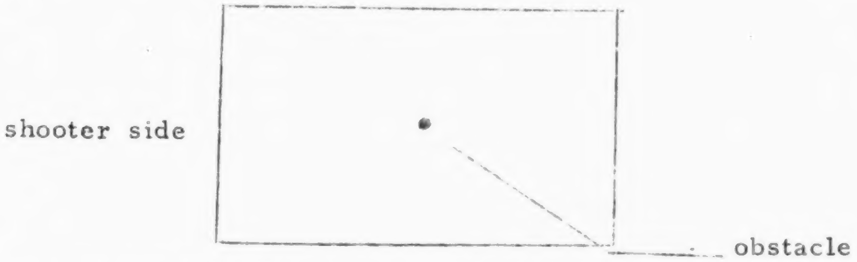
Expected Results

If the students move the shooter to different positions most of the trials shoud result in the bullet (marble) going through the model with no change in direction. Very few of the trials should result in the bullet striking the post or posts located within the model.

Responses to Interpretation Questions

1. There is something inside the model but it is very small as compared to the size of the interior space.

2. Top View



3. The students should recognize that Rutherford could generalize that the center of an atom must be a small, compact, dense portion that is surrounded by empty space. They should also see the similarity between Rutherford's work and what they did in this investigation.

A REAL PUZZLER

OBJECTIVES

Processes

1. Describe qualitative characteristics of objects and events. (13)
2. Construct one or more ideas from a set of observations. (24)
3. Identify the data that supports an idea. (25)
4. Distinguish whether or not an idea is supported. (26)

Concepts

1. A model is based on both evidence and assumptions.
2. The extended model of matter includes the following ideas:
    a. All matter is composed of very small particles called molecules.
    b. There are spaces between molecules.
    c. Molecules are always in motion.
    d. Molecules move farther apart when heated and closer together when cooled.
    e. Molecules exert forces.
    f. Molecules are made up of one or more simpler particles called atoms.
    g. An element is composed of atoms of the same kind.
    h. Compounds are formed when two or more different kinds of atoms join together.
    i. An atom has a dense inner mass surrounded by mostly empty space.

TEACHING SUGGESTIONS

Preparation

1. Prepare the solution for Test Tube B by pouring 40 ml of nitric acid into 60 ml of water. Place approximately 5 ml of the solution in each B test tube.

2. Place copper filings to a depth of about 5 mm in each of the A test tubes.

3. Make an overhead transparency of the puzzle. (Page 326)

4. Make an overhead transparency of all the concepts listed on Page 321 with the heading: A MODEL OF MATTER.

5. Make sure that an overhead projector is available for the second day of this investigation.

Cautions

1. Have students wear goggles and also aprons, if available.

2. Have students slide the copper filings into Test Tube B.

3. Remind the students not to smell the brown gas.

4. Ventilate the room adequately.

Procedure

1. Introduce the investigation by posing the following problem:

   A student was given a triple beam balance, ruler, and a rock. After using the equipment, the student made the following statements:

   a. The mass of the rock is 45 g.
   b. The volume of the rock is 20 ml.
   c. The length of the rock is 4 cm.
   d. The rock is composed of mica and quartz.

   Which statements are supported by data that the student could have obtained using the equipment supplied to him? Which statements are not supported by such data?

The students should suggest that a and c are supported by the data. Each of these statements can be found using the instruments provided. Avoid, if possible, any discussion of the accuracy of the instruments by simply telling the students that the quanitative data is accurate. The students should suggest that b and d are not supported by the data since they cannot be determined by using the instruments provided.

2. Explain to the students that they are going to perform an experiment to verify some statements made by another student. Show the students the materials they will need and discuss the procedures and techniques they will use. Be sure to point out the appropriate cautions.

3. Have the students complete the procedure and clean up before beginning the interpretation questions. If the interpretation questions are not finished by the end of the period, they should be completed as a home assignment.

4. The next day discuss the interpretation questions with the students. Encourage debate as long as students can support their arguments. Statements 1, 4, 8, and 12 represent observations. These observations, like earlier observations, support ideas about the structure of matter.

   Ask students for an observation from this investigation that supports the idea that there are forces between molecules. (The meniscus in Test Tube B.) Discuss observations in 2-10, 2-12, 2-13, and 2-19 that also support this same idea.

   The students probably detected an odor coming from the gas in this investigation. This observation helps support the idea that molecules are always in motion. Point out that this idea is supported also by observations made in 2-9, 2-14, 2-16, and 2-17.

   The students should see that all of the statements listed for Interpretation 2 are based on assumptions. As the discussion proceeds, list the assumptions on the chalkboard along with the titles of the related activity.

Assumption	Related Activity
2	2-18
6	2-28 and the activities that lead up to 2-28: 2-23, 2-24, 2-25, 2-26, and 2-27
9	2-28 and the activities that lead up to 2-28: 2-23, 2-24, 2-25, 2-26, and 2-27
10	2-9, 2-14, 2-16, 2-17
11	2-10, 2-12, 2-13, 2-19
3	2-8, 2-11, 2-15
5, 7	None

You can now develop Concept 1. Refer the class to 2-6 to point up the idea that a model is made of observations and assumptions.

5. Students are now ready to develop a model of matter. Use a jigsaw puzzle analogy. On an overhead projector show the students the pieces of a jigsaw puzzle. Include several pieces that do not belong with the others and omit the piece containing the letters MAT. (See Page 326.) Ask the students how they would attempt to put the jigsaw puzzle together. They may suggest matching easy shapes or colors. Ask one student to complete the puzzle. The student should be able to put together the puzzle except for the missing piece. Ask another student what the picture describes. The student may say it describes a model of matter or water or something else. From all of this, the students can see that: a) some patterns are easy to put together; b) other patterns were hard to put together; c) some pieces do not fit the picture; and d) the finished picture is still incomplete.

   Show the students the second transparency. Students should notice that Concepts b, c, e, f, g, and h have been discussed in this investigation. On the other hand, two of the ideas, d and i, although accurate statements about matter, are not evident from anything the students have observed.

Finally, compare this verbal model with the jigsaw puzzle:

1. Like the puzzle, this model represents a "picture" - a model of matter.
2. Like the puzzle, this model is built of pieces - ideas built from observations and assumptions.
3. Like the puzzle, this model is incomplete. It only represents ideas we have been able to develop from the limited observations made since Investigation 2-1. Additional research might give more detail, but the model will probably never be perfect.

Expected Results

When Test Tube A is poured into Test Tube B, the students should see the following reaction:

a. A brown gas appears above the liquid.

b. Bubbles form in the liquid and move toward the surface of the liquid.

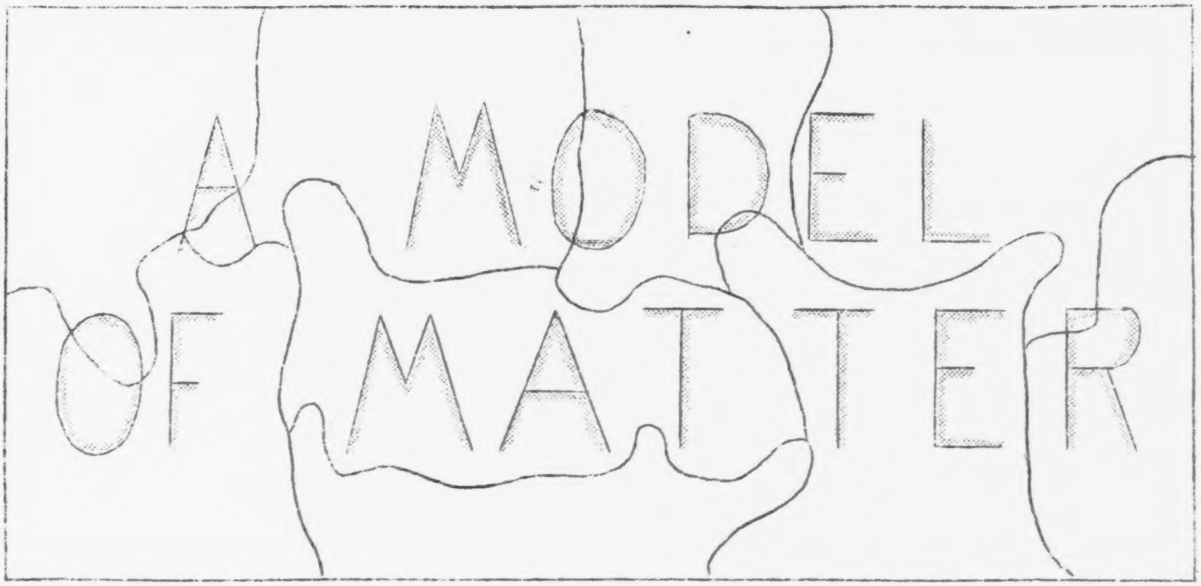
c. The colorless liquid turns blue.

d. Test Tube B becomes warm.

Responses to Interpretation Questions

1. The following statements are supported by the investigations: 1, 4, 8, and 12.
2. The following statements are not supported by this investigation: 2, 3, 5, 6, 7, 9, 10, and 11.
3. Students' responses will vary.

A REAL PUZZLER


A MODEL
OF MATTER

Cut the pieces of the jigsaw puzzle in any fashion. The only essential is that the letters MAT be on a single piece of the puzzle.

SCIENTIFIC MODELS

During this entire phase, students have been collecting evidence and have now come up with a possible model for the structure of matter. They have not, however, talked much about other kinds of models. Nor have they considered models that were discarded when new information became available. The purpose of this investigation is to expose the students to some models that possess these two characteristics.

High ability students can carry out an independent or group library assignment. The student should choose one of the models in the following or a similar list:

1. Ptolemy's model of the solar system
2. Copernican model of the solar system
3. Eudoxian model of the solar system

Before beginning the work contact the librarian for assistance. The students should be encouraged to use as many different references as possible (including encyclopedias, text books, filmstrips, film loops, and overhead projectuals) for compiling information and presenting it to the class.

When reference work has been completed, have selected individuals or groups report to the class. Then have a discussion in which the following points are developed:

1. A model is constructed on the basis of available observations.
2. As additional observations are made, the model may be modified, or it may be discarded and a new model used as a replacement.
3. Some models withstand addtional observations with little change.

For average ability students, select two models and have the entire class study both of them. Choose a pair of models in which one has replaced the other; for example, Ptolemy's model vs. Copernicus' model. If this approach is used there must be sufficient numbers of references for all members of the class. Preferably these should be in the classroom, but if the library has adequate numbers of references, the activity might be done as library research. The discussion at the end of the research should be essentially the same as suggested above for high ability students.

For low ability students construct a study sheet that compares two models, one of which replaced the other. The discussion should bring out the same points as the discussion for high ability students.

A reference that may be helpful in reinforcing your background is the chapter entitled "Universal Gravitation and the Solar System" in the textbook, "Physics" of the Physical Science Study Committee.

2-34

ATOMIC MODELS

This may be used as one of the culminating activities for the work in Phase Two. The primary source of information is Our Friend the Atom. Chapters 1 through 12 refer to various models ot the atom that have been developed and, in some cases, cast aside throughout the history of man. Use the portions of the reference that are appropriate for the ability level of the students. The amount of historical detail to be included depends upon the amount of time available and the degree to which you feel that students will benefit. Possible approaches to this work are listed below.

1. Give students a list of people who contributed or modified atomic models along with a list of statements that each might have made concerning their contributions. Have the students match each statement with the appropriate person. (See Pages 330-331.)

2. Have students construct a time line of events and people associated with the development of atomic models.

3. Have students write a newspaper article tracing the history of the development of atomic models.

4. Have students construct a series of statements, each of which summarizes the contribution of one scientist to the development of atomic models.

CONTRIBUTORS OF IDEAS FOR AN ATOMIC MODEL[1]

Statements that might have been made by 12 different scientists who contributed ideas for various atomic models are listed below. The names of the scientists are given on the next page. Match the two by writing the letter of the appropriate statement before the name of the contributor.

A. I was the first to guess the particle nature of materials. I likened the grains of sand on a beach to the particles of water.

B. I have accurately measured and compared the amounts of materials before a chemical reaction and the amounts after the reaction. By studying these facts, I am able to propose a new theory of matter. I theorize that each element consists of minute particles called atoms.

C. I believe that light rays are composed of a fast stream of extremely small particles that move in all directions from a source. To me, all things - solids, liquids, and gases - are composed of atoms.

D. I was the first to realize and explain the relation between energy and matter. I have also shown that energy can be produced from matter.

E. I have observed that when one rubs his foot across a carpeted floor and then touches a piece of metal, a shock is felt.

F. I believe that basic elements are visible to the eye and noticeable to the touch and that there are four qualities of matter, hot, cold, moist, and dry.

G. I have observed that extremely small particles are capable of penetrating and going through apparently solid metal, just as if a bullet were going through sawdust. Even after the particle has gone through the material, there is no evidence of a hole or marking on the matter.

H. During many months of experimentation, I have observed that uranium gives off a strange kind of radiation that fogs photographic plates right through their protective wrappers.

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[1] Adapted from Haber, Heinz. Our Friend the Atom. pp. 20-83

I. With the aid of a powerful microscope I have observed in water tiny bits of matter that tremble, vibrate, and dance around without stopping. I believe these "creatures" to be even smaller that the smallest one-celled plants and animals.

J. I believe matter is made up of tiny "uncuttable" particles just like an earlier thinker. But I wonder what could hold these atoms together to make a metal or rock so strong - perhaps it is hooks or magnetic attractions.

K. I wanted to find what substance gave out strange radiation. While looking for it, I discovered two new elements.

L. While observing vacuum tubes, I accidently discovered some mysterious rays that showed the bones of my hand on a fluorescent screen.

1. _____ Thales
2. _____ Robert Brown
3. _____ John Dalton
4. _____ Democritus
5. _____ Ernest Rutherford
6. _____ Wilhelm Roentgen
7. _____ Aristotle
8. _____ Henri Becquerel
9. _____ Albert Einstein
10. _____ Pierre Gassendi
11. _____ Isaac Newton
12. _____ Marie Curie

MATERIALS AND EQUIPMENT

Phase Two

2-1. Separating a Mixture

1" x 3" plastic vials with caps, 20
funnels, 20
filter paper, 1 box
beakers, 400 ml, 20
magnets, 10 to 20
sieves or strainers, 20

a mixture of the following:
- graphite
- iron filings
- salt grains
- chopped cork
- sugar grains
- rice
- wash pebbles
- colored sand

2-2. Separating Substances by Sedimentation

plastic columns, 20
#9 solid stoppers, 20
ring clamps and stands, 20
sorted sediments, 200 cm^3 of each size
1" x 3" plastic vials with caps, 100

2-3. Separating Substances by Filtration

timing device
ring stands, 20
ring clamps, 20
test tubes, 18 x 150 mm, 100
watch glasses, 20
#1 solid rubber stoppers, 20
burette clamps, 20
filter paper, 100 sheets
beakers, 250 ml, 20
funnels, 20
sugar
sand
calcium carbonate

2-4. Separating Substances by Chromatography

chromatography paper, sheets, 20
bank pins, 20
green food coloring
collecting bottles, 8 oz., 20

2-5. A Description of Matter

NONE

2-6. Making Scientific Models

clean milk cartons, 1/2 pt., 20
spheres, 20
washers, 20
wooden cubes, 1 cm^3, 20
plastic egg, 1
clay

2-7. Heating and Cooling a Liquid

large containers or beakers, 20
small flasks, 20
ice
glass tubing, 6 mm diameter, 20
one-hole stoppers to fit flasks, 20
marking pencil

2-8. Dye and Water

large glass containers, 20
methylene blue dye
timing device
eye droppers, 20
paper towels

2-9. Paper Towels and Water

small beakers, 20
strips of paper towel

2-10. Ball and Ring

ball and ring apparatus, 20
heat sources, 20
beakers, 400 to 600 ml, 20
asbestos pads, 20
goggles, 40

2-11. Glass Slides and Water

glass slides, 40
beakers, 400-600 ml, 20

2-12. A Paper Clip and Water

paper clips, 1 box
beakers, 400 ml, 20

2-13. The Unknown in a Bag

paper bags, 20
moth balls, paradichlorobenzine, 20
onion pieces, 20

2-14. Ice Cubes

evaporating dishes, 20
ring stands, 20
ring clamps, 20
goggles, 40
heat sources, 20
wire gauze pads, 20
ice cubes, 20

2-15. Swirling Smoke

hydrochloric acid (conc.)
ammonium hydroxide (conc.)
test tube, 18 x 150 mm, 1
eyedroppers, 2
beakers, 400 ml, 2
glass plates, 4" x 4", 2

2-16. Observing Filter Paper

ring stands, 20
ring clamps, 20
filter paper strips, 40
ammonium hydroxide, (conc.), 20
phenolphthalein solution, bottles, 20
forceps, 20
paper clips, 20

2-17. Alcohol and Water

methyl alcohol (ditto fluid), 1000 ml
eyedroppers, 20
graduated cylinders, 100 ml, 40

2-18. A Set of Glass Tubes

beakers, 250 ml, 20
capillary tubes, sets, 20
mercury, 2 pounds
metric rulers, 20

2-19. An Unusual Balloon

electric vacuum pump
rubber balloons, 3
bell jar
sealing compound

2-20. Classifying Observations of Matter

NONE

2-21. From Many to One

NONE

2-22. Extending the Model of Matter

NONE

2-23. Heating an Orange-Red Powder

mercuric oxide, 5 grams
test tubes, 18 x 150 mm, 5
one hole stopper, 1
glass tube, L-shaped, 1
rubber tubing, 60 cm
solid stoppers, #1, 4
water container, 1
wood splints, 5
bunsen burner, 1
burette clamp, 1
ring stand, 1
goggles

2-24. Liquid X and Zinc

sulfuric acid, 150 ml
mossy zinc, 100 grams
3/16 rubber tubing, 60 cm lengths, 20
glass tubing, 6 mm, 20
test tubes, 18 x 150 mm, 60
test tubes, 25 x 200 mm, 20
goggles
one-hole stopper, #4, 1
glycerine
solid stoppers, #1, 3
water tanks, 2
triple beam balances, 10
wooden splints, 80
ring stands, 20
burette clamps, 20
or
pegboard stand and clamps, 20

2-25. Electrolysis

test tubes, 18 x 150 mm, 4
copper wire, #14 plastic insulated, 1 meter
power source, 12 volts
wood splints

2-26. Bubbling Waters

hydrogen peroxide, 3 per cent, 500 ml
test tubes, 25 x 200 mm, 20
test tubes, 18 x 150 mm, 80
one-hole stoppers, #4, 20
glass bend
rubber tubing, 3/16", 60 cm, 20
solid stoppers, #1, 80
water tanks, 20
wooden splints, 40
ring stands, 20
burette clamps, 20
graduated cylinder, 100 ml, 20
manganese dioxide powder
goggles

2-27. Gas from Liquid W and a Ribbon

hydrochloric acid, 100 ml
magnesium ribbon, 25 cm, 4
glass bends, 4
rubber tubing, 3/16", 60 cm, 4
one-hole rubber stoppers, #4, 4
solid rubber stoppers, #1, 12
test tubes, 18 x 150 mm, 12
water tanks, 4
wooden splints, 20
ring stands and bases, 4
burette clamps, 4
goggles
apron
test tubes, 25 x 200 mm, 4

2-28. Distinguishing among Substances

samples of various compounds and elements

2-29. Rubbing Substances Together

PSSC Electrostatics Class Kit that includes cotton cloth, wool cloth, clear cellulose acetate strips, vinylite strips, styrofoam ball, and string

ring stands, 20
ring clamps, 20
graphite in alcohol suspension
or
India ink

2-30. Electricity from Chemical Substances

beakers, 400 ml, 10
zinc strips, 10
copper strips, 10
sulfuric acid, 250 ml
wire leads, 10 pair
voltmeters, 10

2-31. A Big Model of a Small Shooting Range

models, 10
marbles, 10
marble shooters, 10

2-32. A Real Puzzler

nitric acid, 40 ml
test tubes, 18 x 150 mm, 40
copper shot, 20 grams
gas collecting bottles, 8 oz., 20
goggles, 40
aprons, 40

2-33. Scientific Models

NONE

2-34. Atomic Models

NONE

PHASE THREE. LIVING STRUCTURES

Overview

Because of the marked physiological changes taking place in boys and girls in the age range typical of the seventh grade, these students are particularly interested in their own bodies. Phase Three of the Grade Seven Science Program capitalizes on this interest through a study of the structure and function of the human body.

In addition to the relevance of the content to the students, Phase Three has two other benefits: 1) It reenforces the processes and concepts developed in Phases One and Two; and 2) It gives students an opportunity to operate on their own.

In the first investigation, students learn that it is not always easy to distinguish between living and non-living things. They are then given a series of investigations (3-2 to 3-25) related to digestion, breathing, circulation, and sensing and reacting. Finally, the students are asked to make an independent investigation of one of three suggested aspects of personal health: nutrition, smoking, or disease and life expectancy. When the students have completed their own work, it is important that some of them, at least, report to the entire class so that everyone benefits from the findings in all three areas.

Independent work, followed by sharing of results, would seem to be an appropriate experience for the close of a year devoted primarily to the skills and processes of science.

3-1

GROUPING OBJECTS

OBJECTIVES

1. Identify living and non-living objects.

2. Construct a rule that distinguishes between living things and non-living things.

REFERENCE

Biological Sciences Curriculum Study. Biological Science: Patterns and Processes, Teacher's Handbook. pp. 8-9

TEACHING SUGGESTIONS

Preparation

1. Collect objects in quantities that will allow each group of students about 6 objects, 3 or 4 of which are living--for example, goldfish, turtle, mouse, eraser, stone, and a cup; or frog, earthworm, cricket, glass slide, paper clip, and scalpel. Do not include plants. Have enough objects of each kind so that each group of 4 to 8 students observes the same set. Attach a name tag to each object so that all students will use the same names.

2. Collect additional living things needed for Procedure Item 4, including an assortment of plants. Before students come into class, place these around the room in locations where they can be easily seen.

Procedure and Expected Results

1. Give each group of students a set of the objects. The selection of objects is so structured that most students group them on the basis of the presence of life. The question in Procedure Item 3 may then be answered by a simple statement that one group is living and the other is not. At this point only a few students are likely to specify characteristics of living things. In doing Procedure Item 4 some students may overlook plants as living things.

2. After students have been given time to carry out the procedure, have two or more students make charts of their groupings on the chalkboard.

3. Discuss any variations in the students' charts. If necessary, guide discussion toward agreement on "living" versus "non-living" as a basis for grouping the objects. At this point, close the discussion and assign the following problem for the next class period:

   In which of your two groupings would you place a bean seed? Give your reasons for placing the seed in whichever grouping you choose.

4. Begin the next lesson with a class discussion of the above problem. During the discussion a student may suggest that, if the seed is planted and it germinates and grows, it must be living. If this does not come from a student you may have to make this suggestion yourself.

5. In giving reasons for identifying objects as living things, students may list such characteristics as motion, growth, eating, breathing, reproduction, and removing waste. Use the teacher demonstrations listed below to cast doubt upon these processes as characteristics of living things. As a result of these demonstrations, students should see the difficulties of distinguishing between living and non-living things.

   a. Motion. Is motion possible only for living things? Pour water into a petri dish to a depth of 0.5 cm. Add a number of small shavings of camphor to the surface of the water. Ask a student to describe what happens. Is the camphor alive?

   b. Growth. Is growth possible only for living things? Pour sodium silicate (water glass) into each of two test tubes to a depth of about 3.5 cm. Into one test tube drop a crystal of copper sulfate ($CuSO_4$) and into the other drop a crystal of nickel sulfate ($NiSO_4$). Have the students observe what happens.

   c. Breathing. Is air (oxygen) necessary only for living things? Light a candle and let it burn for approximately 1 minute. Then place a jar over the burning candle. Have a student describe what happens.

   d. Motion, Eating, Growth, Excretion, and Reproduction. Can a non-living substance show more than one of these characteristics? This can be a silent demonstration but a histrionic touch may be helpful.

Try not to let the students see what materials are being used. Into a petri dish placed on an overhead projector, pour dilute nitric acid to a depth of 0.5 cm. The amount of dilution is not critical. Add a drop of mercury. Then place a crystal of potassium dichromate near it in the dish. The mercury will begin to move. It may split in two (reproduction). It may add to its volume by picking up small particles of mercury you drop into the dish (growth). It appears to consume some of the crystals (eating). There is a discoloring of the liquid, which might be termed excretion.

Start this demonstration afresh each period. Dilute the nitric acid with water to reclaim the mercury. Do not wash mercury down the drain.

6. Ask students "In which grouping should human beings be placed?" Regardless of doubts as to the definition of life, there can be little confusion about this question. Immediately switch to a discussion of some of the characteristic functions of human beings. Emphasize those functions which will be considered in the investigations that follow: digestion, circulation, respiration, and sensing and reacting.

TESTING FOODS

OBJECTIVES

1. Demonstrate the tests for carbohydrates, proteins, and fats in actual food samples.

2. State the rule that all foods contain useful chemicals called nutrients.

REFERENCES

Oxenhorn and Idelson. The Materials of Life. pp. 141-146

Lawrence, et al. Your Health and Safety. pp. 125-144

TEACHING SUGGESTIONS

Preparation

1. Prepare a set of food samples for each student group. Place them in baby food jars or paper cups. Nutrient A is fat, Nutrient B is carbohydrate, and Nutrient C is protein. Provide at least five food samples for each of the three nutrients.

2. Prepare testing materials for each student group.

   For Nutrient A (fat): 1 sheet of newsprint per student. Section the paper into blocks so that each food tested may be isolated from the other foods.

   For Nutrient B (carbohydrate): 1 bottle of iodine solution, an eyedropper, and containers, such as test tubes, petri dishes, or beakers, for holding materials to be tested.

   For Nutrient C (protein): 1 bottle of Biuret solution, an eyedropper; 2 small test tubes, and 1 container for holding the test tubes.

Cautions

1. Warn students to be careful not to contaminate other foods when testing Nutrient A. (Fatty foods on fingers can be easily transferred to non-fatty foods.)

2. Tell students that containers must be thoroughly cleaned after each test to avoid contamination.

Procedure and Expected Results

1. With low ability groups it may be desirable to do the investigation part by part, with class discussion preceding each item in the investigation. Higher ability groups can carry out the parts independently.

2. Listed below are some hints on technique that you may suggest to students as you circulate among the working groups. The expected results for each test are also indicated.

   A. FAT TEST. Vigorously rub with clean hands on the newsprint paper a small amount of the material to be tested. Wait a few minutes to allow any water present to evaporate. Then hold the paper up to the light. If there is a greasy spot where the material was rubbed, fat is present.

   B. CARBOHYDRATE TEST. Place the material to be tested in a small container. Add a few drops of iodine. If the material turns a purplish or blue-black color, one kind of carbohydrate, starch, is present.

   C. PROTEIN TEST. Add 10 drops of the Biuret reagent to a test tube containing about 5 ml of water. Add 10 drops of the Biuret reagent to another test tube containing about 5 ml of the solution to be tested. A color change from blue to purple indicates the presence of protein. The test tube containing 5 ml of water serves as a control.

3-3

A TEST FOR ENERGY

OBJECTIVES

1. Demonstrate that foods release heat energy when burned.

2. Demonstrate the ability to record and graph data relating time and temperature change.

3. Construct from experimental data a statement that different kinds of foods release different quantities of heat when burned.

REFERENCES

Jacobsen, et al. The Human Organism. p. 390

Oxenhorn and Idelson. The Materials of Life. pp. 130-131

TEACHING SUGGESTIONS

Preparation

1. Ask each student to bring in a small aluminum foil pan such as frozen potpies come in.

2. Purchase a can of mixed nuts. Peanuts, Brazil nuts, and walnuts are particularly well suited to this activity.

3. Prepare for the overhead projector a grid and the chart form from Page 8 of the student manual.

Cautions

1. Review the proper use of matches.

2. Tell students to use the asbestos pads under their setups, since the nutmeats produce a fairly large flame.

Procedure

1. After the other materials have been distributed, give each group a walnut, a peanut, and a Brazil nut. Have the students write these names in the chart on Page 8 under the columns labeled Nutmeat A, Nutmeat B, and Nutmeat C.

2. Ask students to read the Procedure and then begin work.

3. As students work, check each group to make sure that its wire support is from 2 to 4 cm from the bottom of the pan. Also check to be sure that starting temperature is recorded each time.

4. Begin the post-laboratory discussion by asking three groups of students to record their results on the projectual chart, one group for each kind of nutmeat. Have other groups compare their results with those on the projected chart. Ask for explanations for any differences they observe.

5. Ask individual students to plot on the projectual grid the points for Nutmeat A, Nutmeat B, and Nutmeat C.

6. Have students interpret the graph by asking them to tell which kind of nutmeat released the most energy. Continue this discussion to develop these ideas:

   a. When food is burned it releases energy in the form of heat.

   b. Different kinds of foods release different quantities of heat when they are burned.

7. Students will probably have some difficulty answering Interpretation Item 3. Have them look at Figure 130-1 on Page 130 of The Materials of Life. Tell them that this picture is a clue to the answer. After a brief discussion of the picture, have the class read Pages 130-131 to find out how burning takes place in our bodies.

Expected Results

Students should get the most heat from nutmeats with the highest oil content. The Brazil nut has a very high oil content.

Responses to Interpretation Questions

1. Students' answers should be based on the graph: The line with the greatest slope indicates the greatest release of energy.
2. Not all of the heat energy released is collected.
3. We can assume that a process like this takes place in our bodies because the air we breathe out is warm.

3-4

DIET AND GROWTH

OBJECTIVES

1. State the rule that increase of height and weight are indications of growth.

2. Construct a graph from data relating age and weight.

3. From the graph construct the idea that food is needed for growth.

REFERENCES

Jacobsen, et al. The Human Organism: Science and Daily Living, p. 391

Lawrence, et al. Your Health and Safety. pp. 146-157

TEACHING SUGGESTIONS

Procedure

1. Have the students read the paragraph and study the data recorded in the table. Allow time for questions concerning the plotting of the points. Then have the students construct the line graph, and answer the questions on Page 10. Give help where needed.

2. Discuss the graph and the interpretation questions.

3. Distribute copies of Your Health and Safety and have the students examine Figures 69 and 70. These figures are bar graphs that show the ranges of height and weight that are considered normal for boys and girls at certain ages. Help the students interpret these graphs by asking questions such as:

   a. What is the normal range of height for a 14 year old girl?

   b. What is the normal range of weight for a 14 year old girl?

   c. Compare the normal range of height and weight for a 14 year old girl with the normal range of height and weight for a 14 year old boy.

d. Examine the four graphs. What general statement can you make about the relationship of height and weight to age?

4. Students may be interested in comparing their heights and weights with those shown in the graphs. Provide measuring tapes and scales so that the students can determine their heights and weights. Record the data on the chalkboard and make four projectuals of the overhead similar to Figures 69 and 70. You will need to include ages 12 and 13 along the horizontal axes and will probably have to extend the weight and height columns downward. When the graphs are completed, ask the class if they show the usual ranges of height and weight for 12 and 13 year olds. Emphasize that a wide range is normal and that growth and weight increase are individual matters.

Expected Results

Both Group A and Group B should show an ascending growth line. The line representing Group B will be in a higher position than the line representing Group A, thus indicating that an increase in food intake resulted in an increase in weight.

Responses to Interpretation Questions

1. There was a greater weight gain in Group B because this group was fed more food.

2. The differences in weight between Group A and Group B would have been less.

3. Your weight may increase more slowly than it would otherwise.

4. Your weight may increase and you may grow taller faster than with smaller meals.

Assessment Task

The data in the table below show what happened to four rats in a diet experiment. Two of the rats (Group A) were fed a normal diet that included milk and eggs. The other two rats (Group B) at first were fed the same diet except that milk and eggs were left out. This is called a low protein diet.

Age in Weeks	Weight of Group A in Gms	Weight of Group B in Gms
3	15	15
4	40	40
5	60	40
6	80	40
7	95	60
8	110	60
9	125	60
10	140	60
11	150	60
12	155	110
13	160	130
14	162	140

1. Construct line graphs to represent the above data.
2. What effect does a low protein diet seem to have on weight?
3. When do you think the rats of Group B began to receive the same diet as Group A?
4. Show the weights you believe the rats would gain for four more weeks by extending the graphs of Group A and Group B.
5. From this graph, give one reason why you are told to eat a balanced diet.

Responses to Assessment Task

1. See reference.
2. A low protein diet seems to slow down weight increase.
3. During the eleventh week.
4. The line representing Group B would gradually approach the line representing Group A.

3-5

A ONE-WAY STREET

OBJECTIVES

1. Describe the digestive tract as a continuous hollow tube with an opening at each end.

2. Describe the path food takes while passing through the food tube.

3. State the rule that food must be changed before it can be delivered to all parts of the body.

TEACHING SUGGESTIONS

Procedure

1. After the students have traced the path of food through the food tube, discuss this part of the activity with the class. An overhead projectual may be helpful during this discussion. Point out that food must get from the food tube into all parts of the body. Do not include diffusion and solutions in the discussion, however, since these topics will be investigated later.

2. Have the students complete the Interpretation questions. Then hold a class discussion based on these questions.

3. Have students locate the parts of the human food tube on the torso model. This should help them get a clearer picture of the shape and size of the various parts.

Responses to Interpretation Questions

1. No. The parts of the food tube vary in shape and size.

2. No.

3. The food must be changed into small particles and must be in liquid form before it can be delivered to other parts of the body.

3-6

PASSING THROUGH

OBJECTIVES

1. Demonstrate that starch molecules do not penetrate a membrane but sugar molecules do.
2. State the rule that some molecules will penetrate a semi-permeable membrane.
3. Construct the statement that nutrients must be broken down into smaller molecules before they can pass into the body through the membrane that lines the digestive tube.

REFERENCE

Biological Sciences Curriculum Study. Biological Science: Patterns and Processes. p. 95

TEACHING SUGGESTIONS

PREPARATION

1. Prepare a saturated solution of glucose. Table sugar (sucrose) cannot be used for this activity.
2. Prepare a starch solution. For 100 ml of solution mix 1 g dry cornstarch with 3 ml of distilled water; add 97 ml of boiling distilled water by stirring into the starch paste; cook for two minutes, stirring constantly; cool and store not longer than one week.
3. Cut dialysis tubing into 15 cm lengths.
4. Cut long (40 cm) and short (10 cm) pieces of string.

Cautions

1. Be sure that the outside of the dialysis bag is thoroughly washed before placing it in the container of water.
2. Use clean beakers since students will be tasting the contents.

Procedure

1. Begin this investigation by showing the class a test tube containing glucose and a test tube containing starch. Ask them to identify the contents of the two test tubes by any means of observation that they can suggest. Tell them what is in the test tubes.

2. Ask the students to read the introductory paragraph in the Student Manual and attempt to answer the question. Tell them that in this investigation the dialysis tubing represents the lining of the food tube.

3. Have the students carry out the procedure and answer the interpretation questions.

4. After the students have completed work discuss the interpretation questions. Extend the discussion of the starch molecule by asking the class these questions:

    a. What do a postage stamp and a slice of toast have in common?

    b. Why does your mother add a little flour or cornstarch to gravy before cooking?

    c. How would you compare the cooking time of "instant" potatoes with raw potatoes?

    After the students have attempted to answer these questions, ask them to read Pages 152-155 in Exploring Life Science by Thurber and Kilburn to check their answers.

5. Discuss the reading and stress these concepts:

    a. Gentle heating of starch breaks up its large molecules into smaller ones, which are much different from starch.

    b. Starch grains burst open when potatoes and other starchy foods are boiled. The foods can then be digested more easily in the human body.

6. Select several of the activities suggested in the reading and use them as teacher demonstrations or student activities.

Expected Results

Sugar will diffuse through the membrane but the starch will not.

Responses to Interpretation Questions

1. Sugar passed through the dialysis tubing.

2. Starch did not pass through the dialysis tubing.

3. Because the starch molecule could not pass through the dialysis tubing we can conclude that a starch molecule is larger than a sugar molecule.

4. Starch must be changed to sugar in the food tube before it can pass through the membranes that line the food tube and thus get inside of the body.

Assessment Task

This assessment task may be either verbal or manipulative.

If you were given a test tube, funnel, filter paper, beaker, iodine, Benedict's solution, starch solution, and a sugar solution, how would you demonstrate that starch molecules are larger than sugar molecules?

Acceptable Response:

Combine the starch and sugar. Pour the combined solution into a funnel lined with filter paper, collecting the filtrate in the test tube. The filter paper retains starch; the filtrate tests for sugar with Benedict's solution.

3-7

AN EFFECT OF CHEWING

OBJECTIVES

1. Demonstrate simple tests to identify sugar and starch.

2. Demonstrate that starch can be converted to sugar by the action of saliva.

3. Name starch as a carbohydrate.

REFERENCE

Brandwein, Paul F. Life, Its Forms and Changes. p. 113

TEACHING SUGGESTIONS

Preparation

1. For each student group prepare one dropper bottle of iodine solution and another bottle of Benedict's solution.

2. Prepare a starch solution as described in Investigation 3-6.

3. Prepare a sugar solution as follows: Stir one teaspoonful of glucose into 100 ml of distilled water. Store until needed.

Cautions

1. It is the intent of this investigation that the students discover the sugar test themselves, so do not tell them in advance.

2. This activity may cause some commotion among seventh graders. You may need to give specific directions for collecting the saliva and maintain strict control during this part of the activity. The student supplying the saliva should not have eaten, or chewed gum for at least one hour prior to this investigation.

3. Students must wear goggles when heating a liquid. Remind students of the dangers involved in heating liquids in test tubes.

4. Table sugar will not react with Benedict's solution. Be sure to use a reducing sugar.

Procedure

1. Distribute the materials for Part A, which should be completed in one class period.

2. Collect saliva. Allow students to leave classroom if collecting saliva disturbs the class. If students cannot get enough saliva, have them chew paraffin.

3. If time permits, discuss the results and interpretation questions of Part A at the end of the period. If not, do this at the beginning of the next period.

4. Then distribute materials for Part B and have students complete this part of the investigation.

5. Discuss the results and interpretation questions of Part B.

Expected Results

TESTING THE REACTION OF SALIVA

Test Number	Substances to Be Tested	Results	
		Iodine	Benedict's Solution
Part A	Starch	✓	0
	Sugar	0	✓
	Saliva	0	0
Part B	Starch and saliva	✓	✓

Responses to Interpretation Questions

Part A

1. Iodine was used to test starch. If the iodine turned purple, a starch was present.

2. Benedict's solution was used to test for sugar. If the Benedict's solution turned orange or red, a sugar was present.

3. Saliva did not contain either a sugar or a starch.

Part B

1. The starch and saliva mixture contained a starch and a sugar. Both the iodine and the Benedict's solution changed color.

2. Saliva changed starch to sugar.

3. Thorough chewing insures that saliva comes in contact with the food. Chewing also breaks food into smaller pieces that provide greater surface for contact with saliva.

THROUGH THE AGAR BLOCK

OBJECTIVES

1. Demonstrate the penetrating power of "Liquid R" on a large and a small agar block.

2. Construct the statement that, in equal amounts of time, smaller pieces of food can be digested more quickly than larger pieces.

3. Describe the ways in which thorough chewing aids digestion.

TEACHING SUGGESTIONS

Preparation

1. Twenty-four hours in advance prepare agar blocks. To make the solution, boil 1000 ml of water with 15 g of agar. When the solution is boiling, add 20 pellets of sodium hydroxide and immediately remove from the heat. Because the addition of the sodium hydroxide pellets causes a suddenly increased vigor in the boiling, it is important to use a container large enough to prevent spattering.

   CAUTION: Sodium hydroxide is highly caustic!

   Pour the solution into glass baking dishes, plastic trays, or other containers of appropriate depths. When the agar hardens, cut it into cubes. The large cubes should be approximately 3x3x3 cm and the small cubes 1x1x1 cm.

2. Prepare "Liquid R" by dissolving 1 g of phenolphthalein in 40 ml of ethyl alcohol. Stir the solution into 140 ml of water.

Procedure

1. Distribute the agar blocks and have students complete Procedure Item 1.

2. Distribute the beakers of "Liquid R" and let students complete the investigation. Warn students not to move the agar blocks around in the liquid because the blocks are fragile and break easily. Also, be sure that students clean the razor blades thoroughly after each use in Procedure Items 4 and 5. Otherwise, the blades will carry phenolphthalein from slice to slice of the agar.

3. To open the discussion, draw outlines of a large and a small cube on the chalkboard and ask a student to shade in (preferably with pink chalk) the results he obtained in the investigation. Discuss the results and the five interpretation questions. In relating the investigation to chewing, show the EBF film "The Teeth and Eating," or use some other visual aid that emphasizes proper chewing.

4. In classes with mathematical interest and competence, have the students first compute the surface area of the 3x3x3 cm agar block ($6x3^2=6x9=54$ cm^2). Then, ask them to assume that the block has been "chewed" into 27 blocks, each 1x1x1 cm. Have the students compute the surface area of one small block ($6x1^2=6x1=6$ cm^2) and multiply it by the total number of blocks ($6x27=162$ cm^2). Finally, have the students compare the surface area before and after "chewing," and apply what they find to their own chewing habits.

5. Administer the assessment task, either to selected students orally on a one-to-one basis, or as a written check-up for the entire class.

Expected Results

The smaller block of agar should show a smaller volume unstained by phenophthalein than does the larger block.

Responses to Interpretation Questions

1. The larger block had a larger volume not penetrated by the "Liquid R."

2. Because the volume of starch not penetrated by saliva would be greater in the larger block, the small block would have less starch.

3. Cup B would have less starch remaining. Since the starch particles were smaller in Cup B they would change from starch to sugar more quickly.

4. Cup B would have the most materials that would pass through the walls of the food tube.

5. By chewing foods you break the foods into small particles so that digestive juices penetrate more readily.

Assessment Task

You have one large gum drop and three small ones. If you put all four pieces of candy into your mouth at once and let them dissolve without chewing, which will last longer, the large piece or the three smaller pieces? Explain.

3-9

SOLUTIONS AND DIGESTION

OBJECTIVES

1. Demonstrate that agitation increases the speed of solution.
2. Demonstrate that heat and agitation are superior to agitation alone in increasing the speed of solution.
3. State the rule that the stomach increases the rate with which substances go into solution by agitating and heating.

TEACHING SUGGESTIONS

Preparation

Obtain the hard candies. These should be small and all approximately the same size, but the flavor is unimportant.

Procedure

1. Have students do the activity.
2. Open the discussion by asking students to recall from Investigation 3-6 which substance, sugar or starch, remained within the dialysis tubing and which substance passed through the membrane wall of the tubing. Point out that substances having molecules small enough to pass through dialysis tubing are said to be in solution and, hence, are soluble.
3. Recall Activity 2-3. Develop the principle that particles not in solution can be reclaimed by filtering and particles in solution cannot be filtered out. With some classes this discussion may be expanded. Refer to:

   Jacobson, et al. Materials of the Earth. p. 123

   Oxenhorn and Idelson. The Materials of Nature. p. 123

Expected Results

The time required for the lemon drops to dissolve should decrease with each step of the investigation.

Responses to Interpretation Questions

1. The lemon drop that was heated and stirred dissolved most quickly. The lemon drop that was unheated dissolved most slowly.

2. Your stomach churns and is warm. Both stirring and heating increase the speed with which a substance goes into solution.

3-10

STRUCTURE FOR A PURPOSE

OBJECTIVES

1. Name the function of each part of the digestive tract.

2. Describe how the form of each part of the digestive system fits its function.

REFERENCES

Brandwein, et al. Life, Its Forms and Changes. pp. 112-116

Encyclopaedia Britannica Educational Corporation Filmstrips. The Digestive System.

McGraw-Hill Filmstrips. What Is Digestion?

Microview Slides. Digestive System.

Oxenhorn. The Materials of Life. pp. 55-56

Thurber and Kilburn. Exploring Life Science. pp. 186-192

TEACHING SUGGESTIONS

Preparation

1. Preview the filmstrip, "The Digestive System" and any other available visual aids related to digestion.

2. Display a large chart of the digestive system and the human torso.

Procedure

1. Introduce the activity by explaining to the class that the purpose of this investigation is to summarize the story of digestion.

2. For assistance in answering the interpretation questions refer the students to Investigations 3-5 to 3-9, to the torso, to other available visual aids, and to the references listed above.

3. Circulate as students work. Refer students who are having trouble to appropriate books or visual aids.

4. Begin the discussion of the interpretation questions with the last question (Item 15). Bring out the idea that digestion is a continuous process and not an isolated series of activities. Clarify the term, "system" by referring to the school system, the highway system, the solar system, heating systems, etc.

Responses to Interpretation Questions

1. Your teeth help you to chew food and make the pieces smaller.

2. Saliva helps food slide down the food tube.

3. Your tongue mashes up food and moves it about in your mouth, helping to mix it with saliva. Then it pushes the food mass back into the esophagus where swallowing begins.

4. The starch in the bread becomes sugar by the action of saliva.

5. Bread must go down the esophagus to get to the stomach.

6. The bag-like shape of the stomach enables it to store food for a period of time while the food is being agitated and digested.

7. The materials leaving the stomach are further digested in the small intestine.

8. Digested food is in a semi-liquid condition.

9. Digested foods enter the body through the wall of the small intestine.

10. The length of the small intestine is related to the area of its lining membrane, through which digested foods enter the body.

11. Everything you eat is not digested. Some foods contain materials that the body cannot convert to a soluble form.

12. The undigested portion of food is called waste or feces.

13. The undigested portion of food passes into the large intestine.

14. The opening that allows you to get rid of waste is called the anus.

15. Each part of the food tube helps the body to digest food. Therefore, digestive system is a good name for all of the parts of the food tube considered as a functional whole.

Assessment Task

Below is a numbered list of functions of the digestive system. Match these functions with the parts of the digestive system in the chart at the bottom of the sheet. Place the numbers from this list in the second column of the chart. Parts may have more than one function.

1. Carries food from mouth to stomach.
2. Absorbs digested foods.
3. Moves food around in the mouth.
4. Digests fats, proteins, and carbohydrates.
5. Changes starches to sugar.
6. Collects undigested waste.
7. Agitates and digests food.
8. Empties undigested food from the food tube.
9. Stores food for a period of time.
10. Breaks food into small pieces.

PARTS	FUNCTIONS
Mouth: Saliva	
Mouth: Teeth	
Mouth: Tongue	
Esophagus	
Stomach	
Small intestine	
Large intestine	
Anus	

Acceptable Responses

Mouth: Saliva	5	Stomach	7, 9
Mouth: Teeth	10	Small Intestine	2, 4, 7
Mouth: Tongue	3	Large Intestine	6
Esophagus	1	Anus	8

3-11

A BODY WASTE

OBJECTIVES

1. Distinguish between inhaled and exhaled air on the basis of carbon dioxide content.
2. Construct the statement that carbon dioxide is a product of a life process of human beings.

REFERENCES

Thurber and Kilburn. Exploring Life Science. pp. 212-213

TEACHING SUGGESTIONS

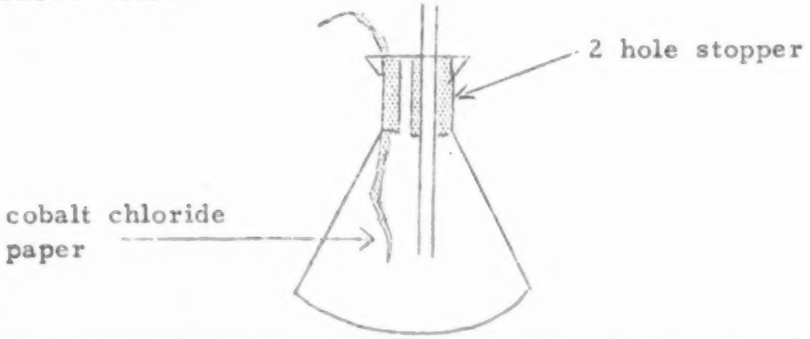
Preparation

1. Limitation in quantity of materials makes it necessary to do this investigation as a demonstration. Refer to Morholt for preparation of bromthymol blue. Prepare sufficient solution to allow 125 ml for each flask.
2. Prepare the glass tubing listed in the student manual.
3. Label Flask A "Inhale" and Flask B "Exhale."

Procedure

1. Begin the investigation by having the students read the introductory paragraph. Ask them to look at the drawing of the equipment in the Student Manual and try to guess what the body waste is.
2. Ask several students to carry out Procedures 2 and 3. Change the straw for each student who uses the mouthpiece.
3. Have each student record his observations in Procedures 4 and 5.
4. Discuss the interpretation items, stressing Objectives 1 and 2.
5. Ask the students if they know of any other tests for carbon dioxide. Have them read Pages 212-213 in Thurber and Kilburn, to learn how to explain and perform the limewater test and the purple cabbage juice test.
6. Ask several students to perform these tests for the class.

7. Water vapor is another gas found in exhaled air. If this fact comes up in the discussion you might demonstrate the test for water vapor that can be conducted with the equipment shown below:



Blow into the flask. Blue cobalt chloride paper turns pink in the presence of water vapor.

Expected Results

The bromthymol solution in Flask A should show no change in color. After three or four breaths, the solution in Flask B should change from blue to green to yellow as the amount of carbon dioxide increases.

Responses to Interpretation Questions

1. The solution in Flask B changed color because of the air which was exhaled into it.

2. The waste material in this investigation is carbon dioxide.

3. Carbon dioxide is a harmful substance if it accumulates in the human body. The body gets rid of this waste material through exhaling.

3-12

MEASURING CARBON DIOXIDE

OBJECTIVES

1. Construct a graph showing the relationship between the amount of carbon dioxide in the lungs and the length of time air is held in the lungs.

2. State the rule that the amount of carbon dioxide in the lungs increases the longer the air is held in the lungs.

TEACHING SUGGESTIONS

Preparation

1. To prepare the barium hydroxide solution, dissolve 35 g of barium hydroxide crystals [$Ba(OH)_2 . 2H_20$] in one liter of water. Heat the solution gently until the crystals are dissolved. A considerable amount of undissolved $Ba(OH)_2$ will remain. Filter the solution through filter paper into a supply bottle. Cover the solution to prevent carbon dioxide from being absorbed into the solution.

Cautions

1. Barium hydorxide crystals are poisonous but the barium hydroxide solution is not. Be careful mixing the solution.

2. Tell the students to be careful not to get any of the barium hydorxide solution in their mouths when breathing through the straw.

3. Some students may find holding the breath difficult. If no one in the group can hold his breath easily for 45 seconds, have the students do only the first three time intervals.

Procedure

1. Have the students read the introductory paragraph. Ask them to look over the list of materials to see if they can identify the indicator that will be used to measure the amount of carbon dioxide exhaled.

2. Review the procedure for the investigation, stressing Caution 2.

3. Have several students place their charts for Procedure 6 on the chalkboard. Ask the other students to compare their results with those on the chalkboard and try to account for any differences.

4. Provide some grid projectuals so that several groups may project their line graphs (Procedure 8).

5. Point out that the students have used a chemical reaction to make an indirect measurement of the amount of carbon dioxide exhaled. With high ability groups introduce the equation for this reaction:

barium hydroxide + carbon dioxide → barium carbonate + water

$$Ba(0H)_2 + Co_2 \rightarrow BaC0_3 + H_20$$

Expected Results

The amount of the precipitate increases with the length of time the breath is held in the lungs. If you do not get enough precipitate to measure, increase the number of breaths exhaled or increase the concentration of the barium hydroxide.

Responses to Interpretation Questions

1. The amount of white material increases as the length of time the air is held in the lungs increases.

2. No. You measured a solid that formed because of the presence of carbon dioxide. The amount of solid that formed depends directly on the amount of carbon dioxide. (You are making an indirect measurement.)

3. For this investigation, the variable is the amount of time air is held in the lungs. Everything else, including the individual doing the exhaling, must be kept constant.

4. Yes. Each team member produces different amounts of carbon dioxide due to body differences, such as mass.

BREATHING DIFFERENCES

OBJECTIVES

1. From a set of observations construct the statement that the amount of respired air increases as body activity increases.

2. Construct the statement that the amount of respired air increases as the amount of carbon dioxide formed within the body increases.

REFERENCE

Thurber and Kilburn. Exploring Life Science. p. 226

TEACHING SUGGESTIONS

Preparation

1. Cut and bend the glass tubing.

2. Insert the glass tubing through the rubber stoppers.

Procedure

1. Have students work in pairs within teams of four students to one set of apparatus.

2. Remind students that for Procedure Items 2 through 5 exhaling must be done as normally as possible.

3. Stress the importance of each student using his own soda straw. Also, explain that the stoppers must be placed firmly in the flasks.

4. Center the discussion around the interpretation questions and bring out the two ideas stated in the objectives above. Then ask the students what other comparisons they might possibly make with the data collected. They will probably suggest comparing the respired air volume of: 1) boys versus girls, 2) tall students versus short students, 3) sports activists versus spectators, etc. Ask for volunteers who will independently collate the data from all of the student manuals and analyze and explain its meaning.

5. Either the class as a whole or a small group may investigate the effects of oxygen and carbon dioxide concentrations on breathing. A good reference is Exploring Life Science, Page 226. It is suggested, however, that the activity described in this reference be altered so that students breathe through three large soda straws instead of covering their faces with plastic bags.

Expected Results

The volume of exhaled air in a normal breath ranges between 20 ml and 25 ml. The volume increases after exercise.

Responses to Interpretation Questions

1. The average volume of air you normally breathe in one minute is less than the average volume of air you breathe after exercise.

2. Your breathing rate after exercising is greater than your normal breathing rate.

3. Carbon dioxide is produced at a more rapid rate after exercising. Removal of the extra carbon dioxide is hastened by an increase in the volume of air respired at each breath and also by an increase in the rate of breathing, though the second is not shown in this investigation.

5. You were asked to rest after each trial so that your breathing may return to normal before you begin the next trial.

3-14

DIFFUSION OF GASES

OBJECTIVES

1. State the rule that the movement of gases through a membrane occurs because of differences in concentrations of the gas.

2. Apply the above rule to the diffusion of oxygen and carbon dioxide in and out of the body through the living membranes of the lungs.

REFERENCE

Thurber and Kilburn. Exploring Life Science. pp. 216-218, 224-225

TEACHING SUGGESTIONS

Preparation

1. Prepare the limewater by adding an excess of calcium hydroxide or calcium oxide to water. Cover the mixture and shake well. Let the solution stand for 24 hours and pour off the supernatant fluid. Filter, if necessary, and keep well stoppered.

2. Obtain acetic acid strong enough to cause a vigorous reaction with the sodium bicarbonate.

Procedure

1. Perform this investigation as a teacher demonstration.

2. If not enough carbon dioxide gas is generated to fill the balloon, increase the concentration of the acetic acid or stretch the balloon again.

3. In the class discussion develop the analogy between the system studied in this investigation, and the interchange of carbon dioxide and oxygen between the lungs and the bloodstream. Point out that there are more carbon dioxide molecules inside the bloodstream than in the air within the lungs. Therefore, the movement of the molecules is from the blood through the lung membrane and into the air within the lungs. Conversely, the concentration of oxygen molecules is greater in the air within the lungs than in the bloodstream. Thus,

the movement of oxygen molecules is from the air in the lungs into the bloodstream. Emphasize that the membranes lining the lungs have a tremendous area through which the exchange of gases occurs. Use the illustrations on Pages 224 and 225 of _Exploring Life Science_ to develop the concept of gas exchange in the lungs.

4. Have the students look at the diagram at the top of Page 216 in _Exploring Life Science_. Ask them to explain what is taking place. After several students have attempted to explain the diagram, ask the entire class to read the section entitled "Diffusion of Gases" to see if the explanations were correct.

5. Refer the students to the diagram at the bottom of Page 216. Ask them what substances used in this demonstration have the same functions as the baking soda and vinegar in the diagram.

6. Have the class examine the diagram at the top of Page 218 in _Exploring Life Science_. (A better visual aid can be made by using colored cut-out circles to be attached to the chalkboard with masking tape.) After a brief discussion of this illustration, have the students read Page 218 to find out what affects the rate of diffusion of a gas through a membrane.

Expected Results

The next day the balloon should be smaller. The limewater should be cloudy or a white precipitate should be on the bottom of the jar. The limewater in the jar without the balloon should be clear.

Responses to Interpretation Questions

1. became smaller
2. turned cloudy
3. remained clear
4. into the limewater; because the limewater became cloudy in the jar that contained the balloon
5. through the many tiny openings in the balloon

3-15

HEARTBEAT

OBJECTIVES

1. Construct a procedure to test an idea.
2. Demonstrate a procedure to test an idea.
3. Distinguish whether or not an idea is supported.
4. Construct a statement that describes in words what a set of data shows.
5. State the rule that there are many factors that affect pulse rate.
6. Demonstrate the ability to express a group of data in terms of average and range.

REFERENCES

Johnson, The World of Statistics. p. 21

Oxenhorn. Built for Living. pp. 67-68

TEACHING SUGGESTIONS

Preparation

1. Obtain The World of Statistics by Johnson from the Mathematics Department. Read Page 21 carefully. The information is presented simply and will provide a background for the statistics used in this investigation and the two that follow.
2. Prepare a form for overhead projection or a piece of tagboard on which each student will record his name and his heartbeat rates while sitting and after exercise. These data will be used in Activities 3-16 and 3-17.

Cautions

1. Since students will be exercising, check health records for handicaps.

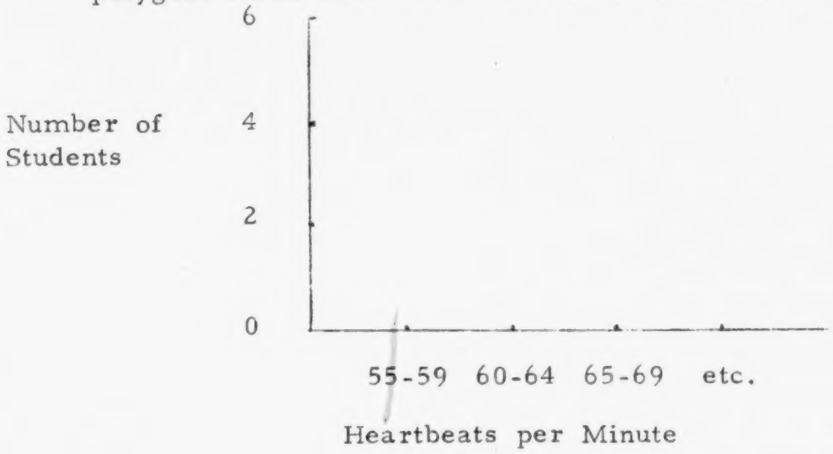
2. If there is a classroom below your room, have students exercise in the hall or use some method of exercising other than running in place.

Procedure

1. Activities 3-15 and 3-16 are designed to prepare students for Activity 3-17, which is an independent investigation concerned with factors affecting heartbeat. In Activity 3-15 procedures are explicit, but the tabulation and organization of data are left to the student; thus some degree of independence is required. Many questions will arise, but encourage students to provide their own answers.

2. If students have difficulty in determining a way to detect heartbeat, point out that the pulse can be felt easily by placing the index finger at the wrist, temple, or neck. Emphasize that data should be organized but that the student will decide on his own method for doing this.

3. Some students will probably have difficulty with Procedure Items 6 and 7. Actually, the students are making a frequency polygon. The axes should be constructed as follows:



4. Provide direction where you feel it is necessary. In less able classes most of the students may need assistance with each step in the procedure. With such students it may be helpful to work through the investigation step by step. For example, ask the entire class to decide upon a method for determining how many times a heart beats in one minute. When everyone understands the method, go on to Procedure Item 2. Record these results on a chart on the chalkboard before continuing with Procedure Item 3. Follow this pattern for the entire investigation.

Expected Results

The data should support the hypothesis that exercise causes the heart to beat more rapidly. The graph should show a wide range in heartbeat rates.

Responses to Interpretation Questions

1. Yes, the data support the idea that exercise causes the heart to beat more rapidly. The table shows that the heartbeats per minute are greater after exercising than while sitting.

2. One way to increase confidence in the conclusion is to measure the heartbeats of more people.

3. For students in this class the average heartbeat rate increased with exercise.

3-16

MORE ABOUT HEARTBEAT

OBJECTIVES

Refer to Activity 3-15.

TEACHING SUGGESTIONS

Preparation

1. The day before work on this activity begins, tell students that they must know their weights.

2. Alert the Health Center to the possibility that a few forgetful students may be sent there to be weighed.

3. Prepare a grid for use on the overhead projector. If a projector is not available, a chalkboard grid may be used.

4. You might also prepare, for overhead projection, some cartoon stick figures that you can use to introduce the discussion of the hypothesis.

Procedure

1. Have the students read the introductory paragraph. Follow with a brief discussion of the hypothesis.

2. Have the students go to the board, one at a time, and quickly record their weights and sitting heartbeat rates. It is not necessary to record student names.

3. If some students have difficulty constructing the chart, called for in Procedure Item 2, suggest the following headings:

Student	Weight	Sitting Heartbeat Rate
A		
B		
C		

It may be less confusing for some classes if this chart is used in Procedure Item 1.

4. Seventh grade students have not constructed scatter diagrams before. Clarify the directions given in Procedure Item 3. For less able students, develop the graph as a class activity, using a chalkboard grid or one projected by the overhead.

5. After students have had an opportunity to plot their own scatter diagrams, use a projected or chalkboard grid to verify the plotting by having individual students quickly locate the points. Ask students to compare their graphs with the class-developed one.

6. Use Interpretation Items 3 and 4 to point out that a scatter diagram can show definite relationships. However, this particular scatter diagram does not show conclusively that there is a relationship between heartbeat and weight.

7. Some individual students or high-ability classes can test the hypothesis further by a statistical analysis of the data. This can be done by:

   a. comparing average heartbeat rates of the heaviest half of the class with the lightest half of the class. (Differences should be slight.)

   b. comparing average heartbeat rates of the 5 heaviest and 5 lightest class members. (Differences should not be great enough to make an inference.)

   c. comparing ranges of heartbeat rates of the heavy half and light half of the class. (The ranges of the two groups should be about the same as, or only slightly less than the range of the whole-class data.)

Expected Results

Students should find no definite relationship between weight and heartbeat.

Responses to Interpretation Questions

1. Points are scattered and no single line can be drawn.

2. Students may have difficulty in constructing the statement because this is probably their first exposure to the scatter diagram. There is no definite relationship between weight and heartbeat rate.

4. Graph A: blood pressure

   Graph B: age

   Graph C: height

5. Graph A: A person with high blood pressure has a higher breathing rate.

   Graph B: Older people have slower breathing rates.

   Graph C: There is no relationship between a person's height and his breathing rate.

6. No relationship between weight and heartbeat rate is shown by the scatter diagram.

3-17

ON YOUR OWN

OBJECTIVES

Refer to Activity 3-15.

TEACHING SUGGESTIONS

Procedure

1. Begin this activity with a discussion of the problem asked in the introductory paragraph, "What other factors may affect the heartbeat rate?" Again picture clues, such as cartoons, can spark thinking about hypotheses other than those listed in the Student Manual. Some additional hypotheses are:

    a. Boys have faster heartbeat rates than girls.

    b. Older people have slower heartbeat rates than younger people.

2. Limit the hypotheses to be tested to four or five. Divide the class so that students can work in pairs.

3. In Activities 3-15 and 3-16 techniques for analyzing data were developed. Review these, especially the technique of scatter diagrams.

4. The development of a procedure may present difficulties for the students. Bring students together after they have developed their individual procedure plans. For each hypothesis, have two or three procedure plans presented to the entire class. Ask the class to react to the plans, offering suggestions if necessary.

5. Determine what data are needed and construct, on the chalkboard, a chart that provides a space to record all of the data from each procedure. Some students may need much more direction than others. Keep the activity as unstructured as possible, but do not allow students to flounder too long.

6. After the data have been gathered, place them in chart form on a ditto and run off a copy for each student.

7. Have teams report their conclusions to the class. Conclusions should be supported by graphic representation of the data as scatter diagrams. Encourage constructive criticism and comparison of ideas. There is no need for all students to report.

OBSERVING CIRCULATION

OBJECTIVES

1. Construct a procedure for observing circulation in a goldfish, tadpole, or earthworm.

2. Demonstrate a procedure for observing circulation in a goldfish, tadpole, or earthworm.

REFERENCES

Brandwein, et al. Life, Its Forms and Changes. pp. 382-383

Encyclopaedia Britannica Film Loop. Circulation - The Flow of Blood.

Morholt, et al. A Sourcebook for the Biological Sciences. pp. 245-246

Oxenhorn. Built for Living. pp. 68-70

Thurber and Kilburn. Exploring Life Science. pp. 117-122

TEACHING SUGGESTIONS

Preparation

1. Several days before the laboratory work is to be done, have the students read the choices listed in the Student Manual and select one. This will give you sufficient time to obtain the live specimens. When determining the number of specimens to order, remember that each specimen, if handled gently, can be used by several succeeding classes.

2. Provide the following equipment: microscopes, stereomicroscopes, paper towels, absorbent cotton, slides, cover slips, petri dishes, warm water, eye droppers, fish nets, and containers for organisms. Encourage students to limit themselves to the equipment provided.

Caution

Caution the students to put goldfish and tadpoles back into water as soon as possible because the organisms are needed for use in other classes.

Procedure

1. After the students select an organism for study, provide references from which **suggestions for procedures can** be obtained. Students may work in pairs.

2. Have students select from the available equipment those items that they need. Provide additional equipment, if students show reasons for needing it.

3. Suggest that students use the following questions as guidelines for their observations:

    a. In what directions does the blood seem to flow?

    b. How is the blood carried?

    c. What factors may affect the rate of the flow of the blood?

    d. Why is the term, circulation of blood, a good description of blood flow?

4. Before the groups actually begin their investigations, set up small group discussions in which all students working with the same organism can share their ideas.

5. While students are working, encourage them to observe circulation in the organisms that other groups are using.

6. During the discussion of results, extend the concept of circulation from the animal to the human body. Some suggestions:

    a. Have the students examine the diagram on Page 233 of Exploring Life Science. Have them trace the path of blood through the body.

    b. Focus attention on the heart in the diagram, pointing out that the heart is a pump. Ask the class to read Page 232 to find out why this is true.

    c. Refer the class back to the diagram on Page 233. Ask why the artist used the colors, red and blue. Have the class read Page 233 to find out what part the blood vessels play in circulation.

    d. Ask the class, "How can blood travel from an artery to a vein?" Tell them to read Page 234 to answer the question.

e. Show the film loop, Circulation - The Flow of Blood. This film uses animated diagrams to show how blood from the heart flows through arteries to the capillaries, returning via the veins to the heart.

f. Use the heart model (BEBCO 0664) and the heart model pumping kit (BEBCO 0666) to illustrate the functioning of the heart.

g. Refer more able students to Pages 117-122 in Life, Its Forms and Changes. Some students might want to carry out investigations on their own.

7. Throughout this study, the emphasis is on normal functioning. However, there may be some interested students who would like to extend the study by testing the effect of different substances on circulation, such as nicotine solutions, adrenalin, sodium chloride solution, and ethyl alcohol. Check A Sourcebook for the Biological Sciences for additional solutions.

3-19

REACTION

OBJECTIVES

1. Identify the characteristics of objects, using different senses.

2. Identify unknown objects by using senses.

3. State the rule that humans react to stimuli.

4. State the rule that it is difficult to reach correct conclusions until several or all sense impressions have been pooled.

REFERENCE

Drapine and Brandwein. The World of Living Things, Teachers Guide. pp. 162-168

TEACHING SUGGESTIONS

Preparation

1. Label a large, covered cardboard box with a question mark. Place in the box a liter-size jar, three-fourths full of lemonade that has been deeply colored with red food coloring.

2. Obtain a blindfold.

Procedure

1. To arouse interest, place before the class the box described above. Obtain 5 volunteers who are to attempt to identify the contents of the box by means of various individual senses. Tell each volunteer that he must follow directions carefully. Each volunteer must be kept aware of the observations made by the others.

2. Blindfold Student 1. Tell him to reach into the box and feel the jar. He may lift it, but may not shake it. Have him record his observations in writing.

3. Blindfold Student 2. Tell him to listen while the teacher shakes the jar, without removing it from the box. What does the sound tell about the contents? Have him write his observations.

4. Blindfold Student 3. Have him smell the contents of the jar and write his observations.

5. Do not blindfold Student 4. Have him look inside the box and write his observations.

6. Blindfold Student 5. Give him a teaspoonful of the liquid to taste, but tell him not to swallow it. Have him write his observations.

7. Ask each of the volunteers to read his observations and then to guess what it was he observed.

8. Ask the other students in the class to decide what they think is in the box.

9. Write on the chalkboard the titles of two previous activities:

   2-6. Making Scientific Models

   2-13. Unknown in a Bag

   Ask the class how these are related to Activity 3-19.

Responses to Interpretation Questions

1. The part of the body used for each impression was:

skin (touch):	feels jar
ear (hearing):	listens to gurgle
eye (seeing):	looks at jar and contents
nose (smell):	smells contents
tongue (taste):	tastes contents

2. The answer to this question is debatable. The information most critical for the identification of the contents was probably gained by taste.

3. One impression probably did not give enough information to allow you to reach a correct conclusion.

4. The answers will vary.

3-20

GOOD TASTE

OBJECTIVES

1. Construct a map of the various taste areas of the tongue.

2. Identify the general areas on the tongue where the sensations of sweet, salt, sour, and bitter occur.

REFERENCES

Lawrence, et al. Your Health and Safety. p. 278

Thurber and Kilburn. Exploring Life Science. p. 293

TEACHING SUGGESTIONS

Preparation

1. Prepare solutions as follows:

   a. Add table sugar to water to make a nearly saturated solution.

   b. Add table salt to water to make a nearly saturated solution.

   c. Add commercial vinegar to an equal quantity of water.

   d. Add two aspirin tablets to 250 ml of water and disperse thoroughly.

2. Place the solutions in clean test tubes in racks and label: sugar, salt, vinegar, and aspirin.

3. Supply sufficient paper cups for each taster to rinse his mouth with water between tastings.

Caution

1. Since the students will be tasting the solutions from the test tubes, be sure the test tubes are thoroughly cleaned.

2. Aspirin solution must be continually agitated.

Procedure

1. Introduce this activity by asking each of four students to taste one of the following: sugar cube, a sour pickle, a salted pretzel, and a piece of orange peel. Ask each student to describe the taste.

2. Have the class read the introductory paragraph and try to answer the question.

3. Distribute the materials for the investigation. Less able students may find it easier to do the activity if they look at the pictures on Page 293 of Exploring Life Science.

4. Any one sample solution can be used by several groups provided no student dips a used swab into it. Discard any sample solution that is thus contaminated.

5. Have the students shake the test tubes before each trial.

6. Ask several groups to copy their completed maps of the tongue on the chalkboard. Have the rest of the class compare results with those on the chalkboard.

7. Refer students to Diagram 139 (map of tongue) on Page 278 of Your Health and Safety to verify their findings.

8. Ask the students how they can taste the difference between dozens of different foods, if there are only four areas of taste on the tongue. Have the class read Page 278, "How do you taste things?" in Your Health and Safety.

9. Extend the discussion by asking, "How is the 'taste' of foods affected by a bad head cold?"

Responses to Interpretation Questions

1. a. Yes. The top of the tongue at the tip and at the sides is sensitive to the sweet taste.

   b. Yes. The middle top of the tongue is sensitive to the sour taste.

   c. Yes. The front edges of the tongue are sensitive to the salty taste.

   d. Yes. The back of the tongue is sensitive to the bitter taste.

2. Some areas of the tongue sensitive to one taste overlap areas sensitive to other tastes.

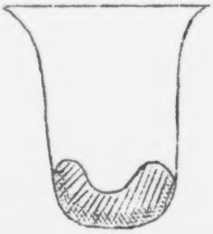
3. There are a number of reasons for less than perfect agreement between students' results and those given in textbooks. There may be inaccuracy in spotting the swabs on the tongue. A swab may be overloaded so that the solution spreads crudely over the tongue. Some students simply cannot make decisions. A recent meal containing strong condiments may dull the sense of taste.

4. Some areas of the tongue are not sensitive to taste.

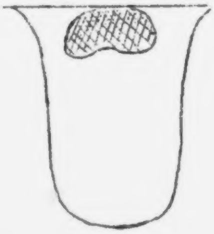
ASSESSMENT TASK FOR 3-20

The marked areas in the following diagrams represent four different test areas of the human tongue.

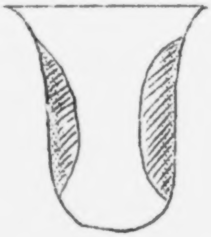
1



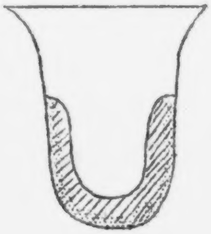
2



3



4



I. Listed below are four things that a student did. In the blank to the left of each action place the number of the taste area which was most likely affected. In the blank to the right of each action name the taste that was most likely sensed.

_____ A. Licked an ice cream cone. __________

_____ B. Gargled with warm water in which an aspirin was dissolved. __________

_____ C. Went swimming in the ocean and got some ocean water in his mouth. __________

_____ D. Drank some lemonade without sugar. __________

II. A student ate a salty pretzel and washed it down with tea containing lemon and sugar. Make one drawing of the tongue showing what areas of the taste would be affected.

Acceptable Responses

I. 2 A sweet

1 B bitter

4 C salty

3 D sour

II. 1. sweet

2. bitter

3. sour

4. salt

All students should include areas 2, 3, and 4. If he has experienced the taste of plain tea, a student might also include the bitter taste area (1).

3-21

THE NOSE KNOWS

OBJECTIVES

1. Identify characteristic odors of selected substances.
2. State the rule that odors are sensed separately.
3. State the rule that olfactory organs tire rapidly.
4. State the rule that a person's past experience influences odor identification.

REFERENCES

Thurber and Kilburn. Exploring Life Science. pp. 292-294

Baltimore County Board of Education. Basic Education Manual, "Using Our Senses." pp. 6-8

TEACHING SUGGESTIONS

Preparation

1. Select at least 6 substances that have distinctive odors. These might include vinegar, butyric acid, a perfume, onion juice, an air freshner, alcohol, chewing gum, and vanilla. Place the substances in capped vials or bottles.
2. Label the containers with capital letters (A, B, C, etc.) and prepare a key to the identity of the substances. Prepare enough sets of the substances so that students may work in groups of 4 to 8.

Procedure

1. At the beginning of the period, place in clear view of all students one petri dish with onion juice or ammonia in it, and another with perfume in it. Do not call attention to what you are doing.
2. Have students recall that they were able to identify certain substances by taste. Ask, "What can you tell about the substances in the petri dishes by smell only?" Allow students to identify the materials, if possible.
3. Have students read the directions. Demonstrate the proper method of smelling by fanning the fumes toward your nose.

4. Have the students carry out the procedure.

5. Before beginning a discussion of the interpretation items, ask students for their identifications of the substances. Then give the correct names.

6. After discussing the interpretation items ask the students if the sense of smell affects the taste of a substance. Have them read Pages 292-294 in Exploring Life Science to answer the question. Some students may want to carry out the activity on Page 294.

Responses to Interpretation Questions

1. Some odors are easily identified and others are not.

2. Yes, odors do not seem as strong after several minutes.

3. Yes, some odors are much stronger than others.

4. Response will vary.

5. You smell each odor separately.

6. Some odors were identified because they were odors that had been detected before.

ASSESSMENT TASK FOR 3-21

A blindfolded student enters a small room. In the room there is a table with the following items on it: several sections of apple, an open bottle of perfume, and a dish of vinegar. Below is a list of statements concerning the student's experiences in the room. Circle the number of each statement that describes a probable experience.

1. At first he will detect only one smell: a combination of odors from the three items on the table.
2. The odor will seem to get stronger the longer he stays in the room.
3. He will like the odor of the apple, but not the odor of the vinegar.
4. He will eventually be able to decide that there is more than one odor in the room.
5. He will be able to identify correctly each item on the table.

Expected Response

Only Number 4 should be encircled. Numbers 1 and 2 are contrary to evidence. Numbers 3 and 5 are possible, but Number 3 is an unpredictable matter of preference, and Number 5 is a matter of the student's prior experience, about which we know nothing.

HEARING

OBJECTIVES

1. Describe the structure and function of the human ear.
2. State the rule that the sense of hearing operates continuously.
3. State the rule that human ears are very sensitive organs.

REFERENCES

Thurber and Kilburn. Exploring Life Science. pp. 286-287

Lawrence, et al. Your Health and Safety. pp. 280-285

Encyclopaedia Britannica Films. The Ear - Its Structure and Function.

TEACHING SUGGESTIONS

Preparation

1. Provide sets of Exploring Life Science.
2. If you do not have an ear model available, obtain a commercially-prepared overhead transparency of a diagram of the human ear, or make such a transparency.

Procedure

1. Introduce this investigation by asking the class to sit very quietly and list all of the sounds they hear. They will probably include such things as students writing, people walking in the hall, moving of chairs or desks, and cars on the street.
2. Discuss the lists with the class. Bring out the idea that our ears are very sensitive organs.
3. Find out what the students know about the structure of the ear by having them identify the major parts and functions, using an ear model or an unlabeled overhead transparency of the ear.
4. Have the students read Pages 286-287 in Exploring Life Science to check on their identifications of the major parts and functions of the ear.

5. Discuss the reading assignment. Ask individual students to label parts of the ear on the transparency. Have each student read orally from the reference those sentences that verify his answer. More able students can refer to Pages 280-282 in Your Health and Safety.

6. Have the students label the diagram and complete the chart in the Student Manual.

7. Use the filmloop, The Ear - Its Structure and Function, as a review for this activity.

8. As a related activity demonstrate biaural listening. Place a student in front of the room and stand immediately behind him. Snap your fingers and have the student point to the location of the sound. Change the position of your fingers from directly behind, to left side, right side, and directly overhead. Discuss any difficulty the student may have in locating the direction of the sound; for example, it is difficult to locate sound directly behind the head. Point out that this is an example of the limitation of a sense organ.

Responses to Interpretation Questions

1. The size and shape of the outer ear help in collecting sound waves.

2. We can increase the reflecting surface of the outer ear by cupping a hand around the ear or by using a funnel.

3. A person can experience ear pain when making a quick descent in an airplane because the pressure within the eustachian tube may not change as rapidly as the pressure on the outer side of the ear drum.

4. Hearing with both ears simultaneously increases ability to locate the direction of sounds.

5. On the average, blind people probably hear no better than sighted people, but they learn to use their ears more effectively.

3-23

EYE STRUCTURE AND FUNCTION

OBJECTIVES

1. Describe observable eye movements.
2. Construct a diagram of the muscles of the eye and label it correctly.
3. Construct statements that eye movements are a result of muscle action; that blinking lubricates the eyes; and that in order to function, an eye must receive light.

REFERENCE

Thurber and Kilburn. Exploring Life Science. pp. 274-285

TEACHING SUGGESTIONS

Procedure

1. Motivate the class for this activity by doing one of the following:
    a. Read a selection from Helen Keller's biography, describing the world of the blind.
    b. Have the students examine the eye model and name as many structures as they can.
    c. Read the poem "The Blind Men and the Elephant" by John Godfrey Saxe on Page 31 of How to Do an Experiment by Philip Goldstein.
2. Have the students complete Part A. They should have little difficulty since the directions are rather specific and they may have already studied the eye in elementary school.
3. Discuss Part A, stressing:
    a. Light plays an important role in vision. One cannot see in the absence of light.
    b. The eye movements that occur during reading consist of a series of jerks, not a smooth movement.

c. The eyeball becomes moist and shiny each time the eye blinks.

4. Discuss the chart in Procedure Item 3. Ask the students to explain possible reasons for differences in blinking rates.

5. To introduce Part B have the students identify the major parts of the eye on an eye model or an overhead transparency of an eye diagram. As each part is identified, ask a student to explain the function. If the students are not sure of a part or function, refer them to Pages 274-275 in Exploring Life Science.

6. Summarize the parts and functions in chart form on the board.

Eye Part	Function

7. Have the students complete Part B in the Student Manual and then discuss the interpretation questions.

Responses to Interpretation Questions

Part A

1. Blinking protects and lubricates the eyes.

2. No clear image can be formed while the eye is in motion; therefore, the eye must fix on a segment of a line of type, then move on to another segment. Thus the eyes move in jerky manner. The eye muscles control these movements and act together, allowing both eyes to move as a single unit.

3. Students should draw the four eye muscles that control eye movements.

Part B

1. The outer parts of the eye can be seen easily.

2. The internal parts of the eye can be studied by dissecting an eye.

MORE USES FOR SCIENTIFIC MODELS

OBJECTIVES

1. Demonstrate the use of a scientific model to explain the action of the lens of the eye.
2. Identify the various parts of an eye.
3. Construct the idea that other animals have eyes similar to the human eye.

REFERENCES

Oxenhorn. Built for Living. pp. 144-146

Thurber and Kilburn. Exploring Life Science. pp. 275-82

TEACHING SUGGESTIONS

Part A

Procedure

1. Review the parts of the eye and their functions. Stress the function of the lens.
2. Have students read the introduction to Part A and then prepare their model lens. Provide squares of newspaper 10 cm x 10 cm.
3. Allow students enough time to work with their models. Then have them read Pages 275-276 in Thurber and Kilburn and complete Part A.
4. In the discussion of Part A stress that the change in shape of the plastic bag caused the change in the appearance of the newspaper print.
5. Tell the students that they will dissect an eye similar to a human eye in the next part of this investigation.

Responses to Interpretation Questions

1. The plastic bag of water was made rounder and thicker.
2. A change in the lens shape allows the eye to focus on both near and far-away objects.

3. Muscles attached to the lens make it thicker when we are looking at near objects and thinner when we are looking at objects farther away.

Part B

Preparation

Obtain steer or pig eyes from local sources. They should be ordered well in advance of their planned use so that the class is ready for this work when they arrive.

Cautions

1. Caution students about the handling of sharp instruments such as scalpels, razor blades, probes, and scissors.

2. Have students wash their hands after the dissection.

Procedure

1. Help students develop good dissection techniques in one or more of the following ways:

    a. Demonstrate some of the important techniques in the dissection.

    b. For less able students, demonstrate the dissection one step at a time and, after each step, have the students carry it out with their own specimens.

    c. Prepare a detailed dittoed dissection guide.

    d. Prepare a visual aid showing the dissection techniques; for example, a chart, an overhead transparency, or a set of slides.

2. Move about the room assisting students when necessary. Rather than answering questions directly try to stimulate thinking by asking appropriate questions.

3. Be sure all students identify the lens.

4. Ask several students to show their drawings and explain them to the class, comparing the animal eye with a human eye.

3-25

THE SENSE OF TOUCH

OBJECTIVES

1. Identify data that support an idea.

2. Distinguish whether or not an idea is supported.

3. Construct the statement that nerve endings are farther apart on some areas of the skin surface than others.

REFERENCES

Oxenhorn. Built for Living. pp. 148-149

Shevick. Matter, Life, and Energy, Laboratory Investigations. p. 51

TEACHING SUGGESTIONS

Preparation

Prepare enough plastic forks so that each group of 3 students has one set. Each set should consist of 3 forks: a. fork with only one prong, b. fork with 2 outside prongs, and, c. fork with 3 prongs.

Procedure

1. Distribute the sets of forks to each group of 3 students. One student should be the experimenter, another the subject, and the third the recorder. Tell the experimenters that they should touch the subject lightly.

2. For lower ability groups, demonstrate the procedure.

3. Begin the class discussion by recording on a chalkboard or overhead chart the group totals for each trial area.

Trial Area	Total Number Right
Palm of Hand	
Tip of Index Finger	
Lower Side of Wrist	
Back of Hand	

4. Have each student group compare its results with the class summary.

Responses to Interpretation Questions

1. Some areas of the hand are more sensitive than others. These areas differ with different people. Generally speaking the finger tips are more senstitive to touch than other parts of the hand.

2. Nerve endings are farther apart on some areas of the skin than on others.

3-26

ON YOUR OWN AGAIN

OBJECTIVES

1. Demonstrate the ability to plan an investigation.
2. Identify appropriate references.
3. Demonstrate the use of references.
4. Demonstrate the ability to order the steps in an investigation.
5. Construct a variety of procedures for carrying out and reporting an investigation.
6. Identify situations in which data are appropriately shown as charts and graphs.
7. Construct charts and graphs.
8. Demonstrate the ability to collect and organize data in a data book.
9. State and describe the results of an investigation.
10. Identify valid inferences from data.
11. Identify relationships revealed by data.

See also the Process Hierarchies for Phase One on Pages 13-15 and 17-19.

TEACHING SUGGESTIONS

Preparation and Procedure

1. At least a week before beginning this part of the program read Activities 3-26 to 3-29 in both the Student Manual and the Teachers Manual.
2. Collect references from the bookroom and from health agencies in the community. Check the school library and make a list of available references related to the three topics: nutrition, smoking, and disease and life expectancy.

3. Collect related transparencies, filmloops, filmstrips, films, and other audio-visual materials.

4. Obtain the basic equipment and supplies that will probably be needed, such as microscopes, petri dishes, culture media, and glassware.

5. You will recall that midway in Phase Three, students selected a hypothesis about heartbeat, and then planned and carried out an investigation to test it. Now, at the end of Phase Three, they can be further weaned and allowed to proceed even more independently. But it is necessary to plan for varying degrees of independence. You, of course, are the best judge of the degree of independence appropriate for the individual students in your classes. In view of the emphasis given to laboratory skills and the processes of science from the beginning of the seventh grade, it seems probable that average and above-average classes will be able to operate on the basis of the suggestions given in the Student Manual, coupled with teacher assistance in obtaining needed references, equipment, and other materials of instruction. You must also offer continuing encouragement, interest, and consultant service as students work on their investigations. Students who cannot work with a high degree of independence may be able to carry out one or more of the investigations in small or in large groups. For classes needing a great deal of teacher direction, it may be wise to abandon the Student Manual and duplicate explicit procedures for one or two investigations that you feel the students can profit from.

3-27

NUTRITION FOR GOOD HEALTH

OBJECTIVES

In addition to the process objectives listed in 3-26, this activity is concerned with both information and attitudes that promote healthful nutritional practices. Stated behaviorally: Having completed this investigation, the student will identify the elements of a health-promoting diet and will demonstrate the ability and willingness to follow such a diet regularly.

TEACHING SUGGESTIONS

See 3-26

3-28

SMOKING

OBJECTIVES

As for Activity 3-27, this activity is concerned not only with the process objectives listed in 3-26 but also with information and attitudes concerning the dangers of smoking. The ultimate behavioral objective is that the student will abstain from smoking throughout his lifetime.

TEACHING SUGGESTIONS

See 3-26.

3-29

DISEASE AND LIFE EXPECTANCY

OBJECTIVES

See 3-26, 3-27, and 3-28.

TEACHING SUGGESTIONS

Procedure

1. Proceed as suggested in 3-26. Insofar as possible, allow each student to gather his own data and devise his own plan for analysis and display.

2. As students attack the first question in the investigation, they will probably see that bar graphs are particularly helpful in organizing the data on disease and life expectancy. If they know very little about bar graphs, have them do Self-instructional Activity A, found on Pages 420-422, of this Teachers Manual. Make ditto masters of these pages and duplicate them so that they are available when needed. The expected results are on Pages 423-424.

3. If students need further direction for Question 1 in the investigation, give them copies of Self-instructional Activity B, found on Pages 425-426. The expected results are on Pages 427-428. These pages, of course, need not be duplicated.

4. Students needing direction for Question 2 in the investigation may be given copies of Self-instructional Activity C, found on Pages 429-431. However, this is recommended only for students who have firmly grasped the general principles of graph-making, because some unconventional techniques make this potentially confusing. The expected results are on Pages 432-433.

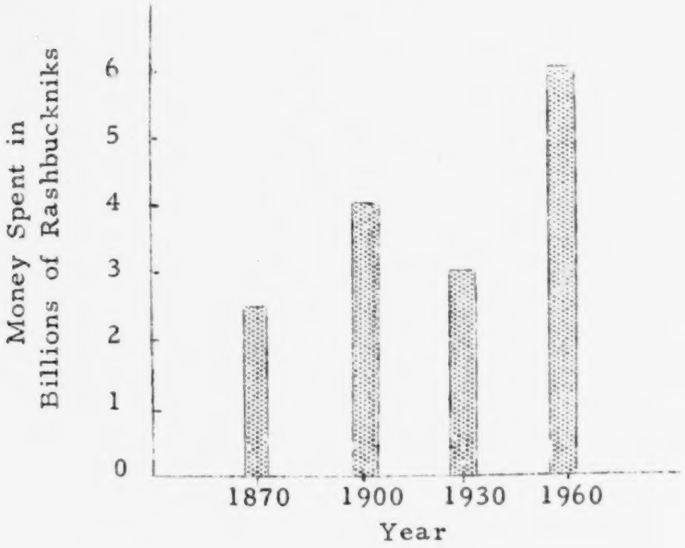
5. Self-instructional Activity D (Page 434) is related to Question 3 in the Student Manual. As does C, this also contains some potentially confusing graphing. The expected results are on Page 435.

SELF-INSTRUCTIONAL ACTIVITY A

A Different Kind of Graph

In order to display and interpret data you have made several kinds of graphs by plotting points on a grid. For some kinds of data such graphs are not very satisfactory, but a bar graph can be helpful. Study the bar graph below and answer the questions.

Amounts of Money Spent by the Government of Lower Slobovia



1. What do the heights of the bars represent?

2. What do the divisions of the horizontal scale represent?

3. What does the thickness of each bar represent?

4. What period of time is represented on the graph? From _________ to _____________, a total of _________________ years.

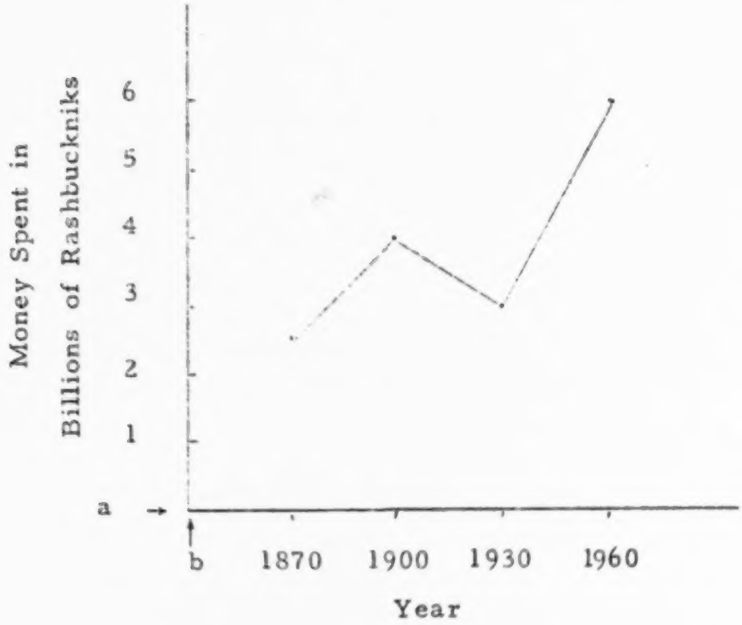
5. What is the range of spending represented on the graph?

6. What was the amount of increase in spending between 1900 and 1960?

7. Because of a shortage of help, the treasurer of Lower Slobovia reports spending records only once every 30 years. Can you tell how much money Lower Slobovia spent in 1885? Why or why not?

A member of the Treasury Department made a point graph of the same data shown by the bar graph. It looked like this:

Amounts of Money Spent by the Government of Lower Slobovia



8. Can you tell what "b" represents in this second graph? Why or why not?

9. Can you tell what "a" represents in this graph? Why or why not.

10. What is the total range of spending represented on this graph? How do you know?

11. Why was the graph line not started at the point where both axes begin (ab) ?

12. What was the amount of decrease in spending between 1900 and 1930 ?

13. Can you tell how much money Lower Slobovia spent in 1885? In 1910? Why or why not?

14. If you did not know the fact given in Item 7, what answer would you give for Item 12? Would your answers be correct? How do you know?

15. Does the point graph give us any information not contained in the bar graph? Explain your answer.

16. In what kinds of situations is a bar graph better than a point graph?

Expected Results for Self-instructional Activity A

1. The heights of the bars represent amounts of money spent in the years shown on the horizontal axis.

2. Each division on the horizontal scale represents a period of 30 years.

3. The thickness of a bar has no meaning. It is merely a way to make the data more visible.

4. From 1870 to 1960, a total of 90 years. Students may count along the horizontal axis from the origin (which could represent 1840), but this is not justified on the basis of information.

5. The range of spending is from 2.5 to 6 billion rashbuckniks (or 3.5 billion rashbuckniks.)

6. 2 billion rashbuckniks

7. We cannot tell how much money was spent in 1885 because no records were kept for this year.

8. The point "b" represents 1840 because it is at a scalar distance that indicates 30 years before 1870.

9. The point "a" represents zero because it is the base line from which all other values are measured on the vertical axis.

10. The range is 2.5 to 6 billion, or 3.5 billion. (Students may be tempted to say: "From 0 to 6 billion but we do not know what "b" represents.) The lowest amount of spending actually shown is 2.5 billion.

11. To begin the graph line at the intersection of the axes would represent that the spending in 1840 was 0 billion rashbuckniks. This is unjustified since the second graph was made from the same data as the first and that contained no information about 1840.

12. From 4 to 3 billion or a decrease of 1 billion. (In this kind of determination the point graph is just as good as the bar graph because we use the plotted data points.)

13. We cannot tell the amount of money spent in either 1885 or 1910. From the statement in Part 7 we have no justification for interpolating between points.

14. We would say about 3 billions for 1885 and 3.5 billions for 1910. These answers would certainly be very doubtful if not totally in error because we have no justification for interpolation between points.

15. From the answers to the above questions we can see that the point graph gives no information not contained in the bar graph. Indeed, without some knowledge of the bookkeeping procedures of Lower Slobovia, we might be led astray and draw some wrong conclusions by taking readings from the lines between points.

16. Bar graphs are not as misleading as point graphs for data that are separated by rather large time periods, for data that represent no logical trend, and, especially, when we have no way of going back to check. A common example is census data, which is taken every 10 years; any value for years between the census years must necessarily be estimated.

SELF-INSTRUCTIONAL ACTIVITY B

Life Expectancy

You may have heard, "Human beings are living longer." What does this mean? Can each of us expect to live longer than our grandparents? Have the causes of death changed over the years? What kinds of diseases must modern man guard against?

1. The table below lists for various years the average age to which a person in the United States could expect to live. These data become clearer if put into the form of a graph. Would a point graph or a bar graph be more appropriate for these data? At what age and what year should your graph start? Why?

Year	Life Expectancy in Years
1900	47
1905	48.5
1910	50
1915	54.5
1920	54
1925	59
1930	59.5
1935	61.5
1940	62.5
1945	65.5
1950	68
1955	69
1960	69.5
1965	70
1970	70

2. After you have completed the graph, answer the following questions:

   a. How many years difference was there between the average age of death in 1910 and the average age of death in 1965?

   b. Between what years was the increase in life expectancy greatest?

   c. What was the average increase per year in life expectancy from 1900 to 1950:

      (1) from the data table?

      (2) from your graph?

   d. If there was a difference in your answers to c(1) and c(2), do you think the difference was significant?

   e. Compare the section of your graph between 1900 and 1955 with the section between 1955 and 1970. What difference(s) do you see between these two time periods?

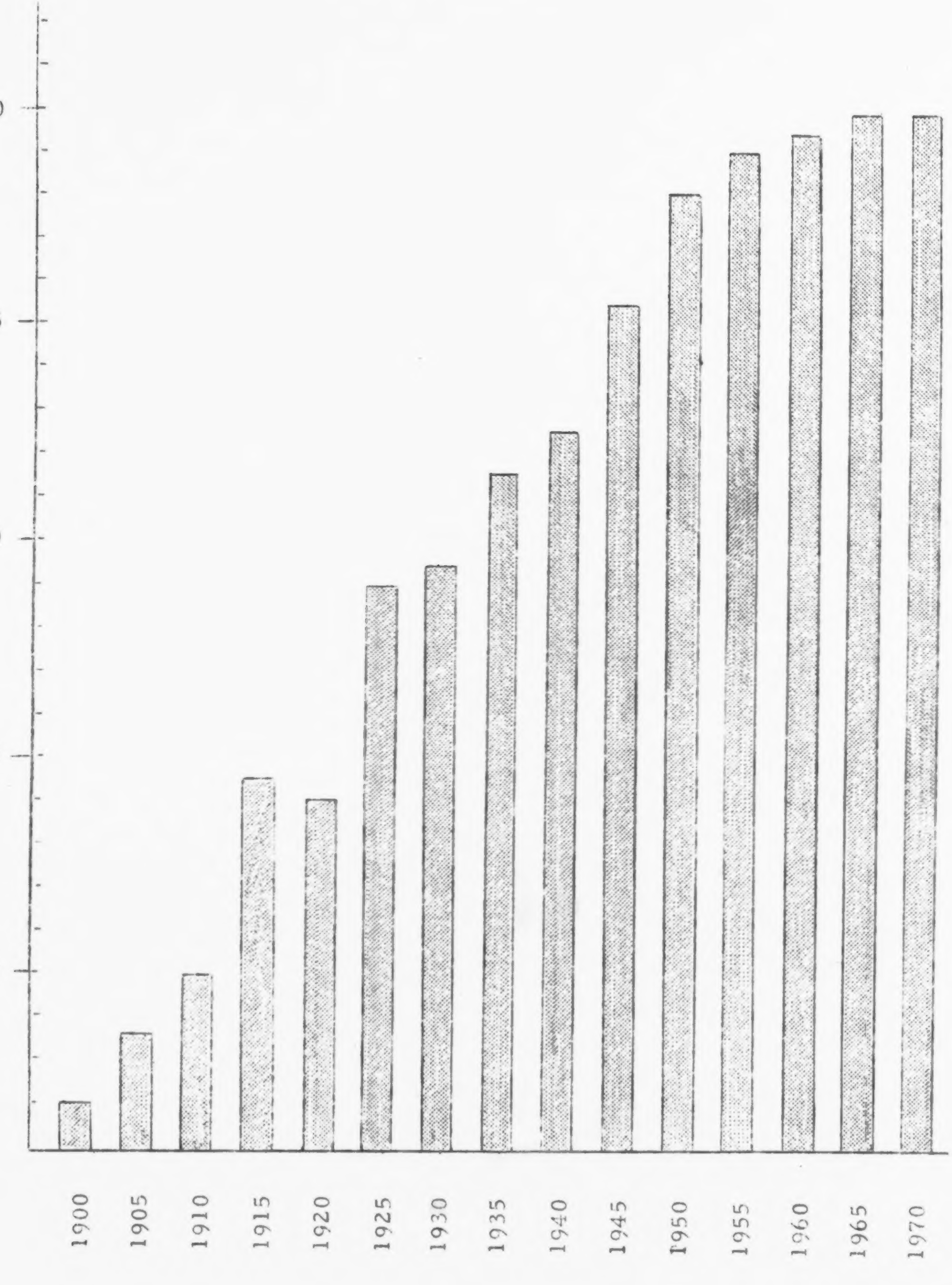
   f. If the data table was printed in 1968, what can you say concerning the data for 1970?

   g. In what way(s) is your graph more useful than the data table?

   h. In what way(s) is the data table more useful than your graph?

Expected Results

1.



2.

a. 20 years. May be found from data table or graph.

b. Between 1920 and 1925. This shows up more clearly on the graph than on the data table.

c. (1) 0.37 (by taking the sum of differences and dividing by the time span)

   (2) p.42 (by taking the average slope between the two dates)

d. Examination of the data table seems to indicate that all figures were rounded off to the nearest 0.5 year. The reasonable thing to do with the two numerals above would be to round them off to the nearest tenth. Thus the answers would become: (1) 0.4, (2) 0.4. The difference would not be significant.

e. There was a fairly constant increase in life expectancy between 1900 and 1955, with minor ups and downs. During the period between 1955 and 1970 there was little increase in life expectancy; that is, the rate of increase of life expectancy was decreasing.

f. The life expectancy for 1970 was projected or estimated. Therefore we cannot have as much confidence in it as we have in the values for the previous years.

g. The graph shows general trends and patterns in life expectancy much more clearly than the data table. Approximate values are easily read from the graph. The answers to Item b and e are more easily obtained from the graph. The answer to Item a was obtainable from the graph about as easily as from the data table. The graph, then, is generally better for the purpose of analysis.

h. Where precise data are needed, the table is more useful.

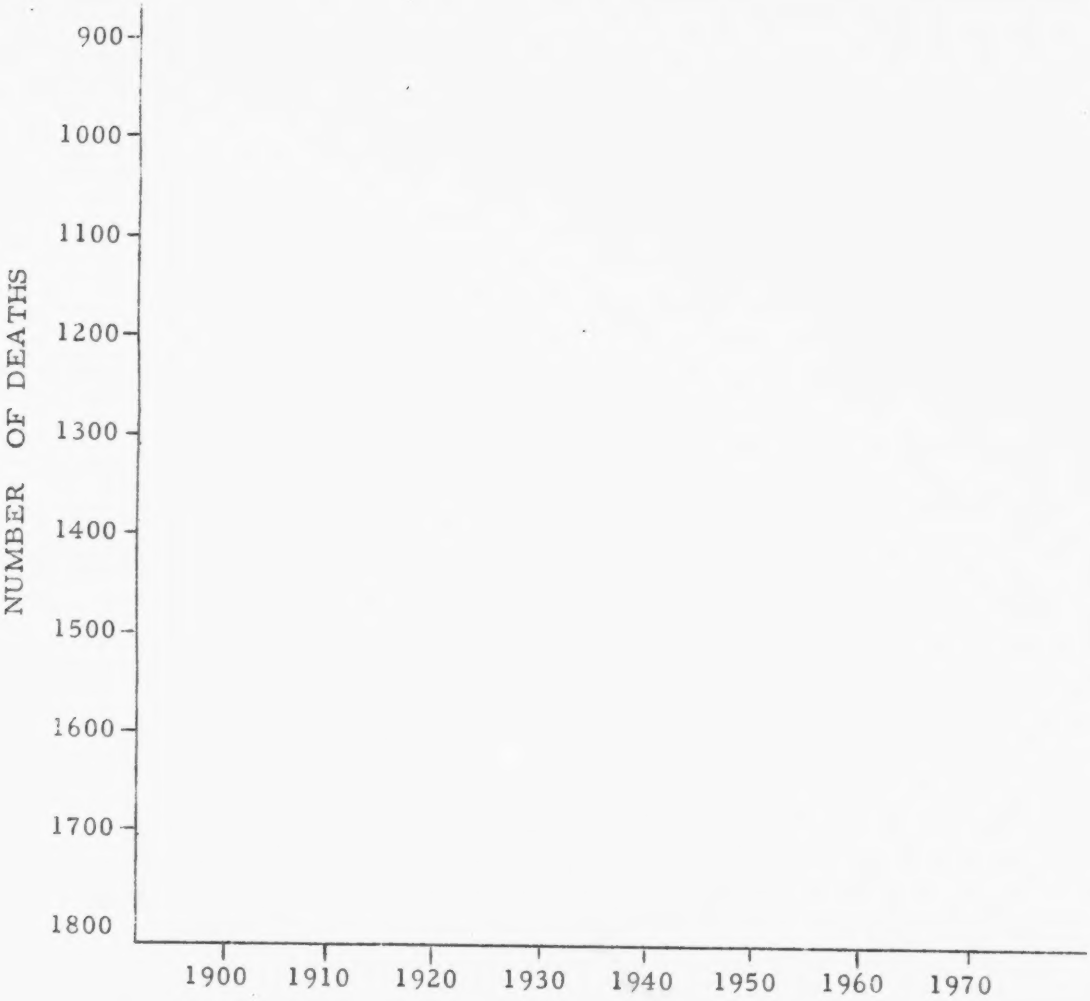
SELF-INSTRUCTIONAL ACTIVITY C

Life versus Death

The table below lists for selected years the deaths from all causes per 100,000 of United States population.

Year	Deaths per 100,000 from All Causes
1900	1770
1910	1498
1920	1310
1930	1132
1940	1078
1950	962
1960	944
1965	942

1. Graph the death rate on the form on the next page. Note that the vertical scale is reversed; that is, it has the largest number at the bottom and goes up to the lowest number of deaths. This is unusual but it is done for a special purpose in this case.


NUMBER OF DEATHS
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
1910
1920
1930
1940
1950
1960
1970

2. Compare your graph with the graph from Self-instructional Activity B. Describe any differences and similarities.

   Differences:

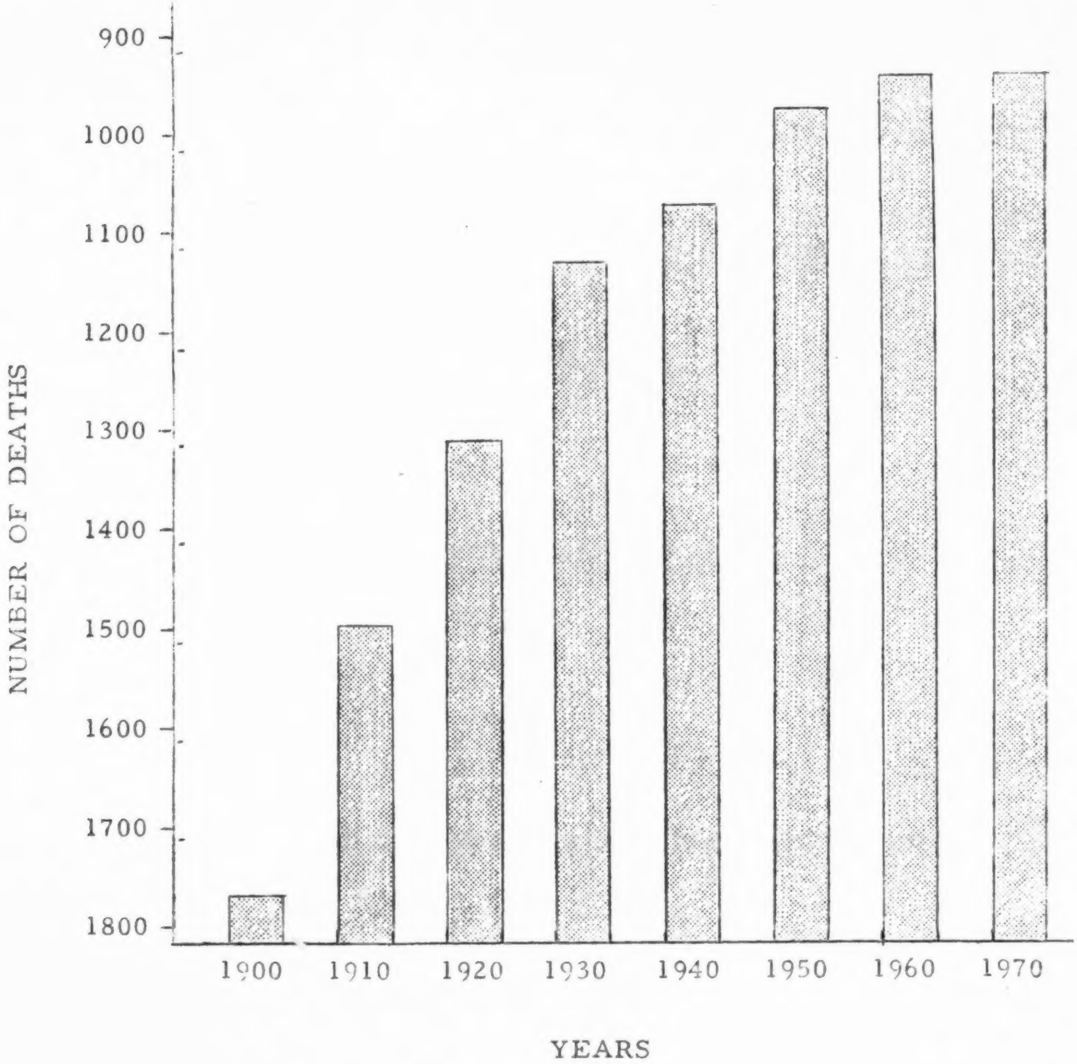
   Similarities:

3. Extend each bar down to the base line and darken the part of the bar from the base line up to the death rate for each year.

4. Compare the graph from Self-instructional Activity B with the darkened parts of the bars in this graph. Is the death rate roughly the opposite of life expectancy?

Expected Results

1. and 3.



2. Differences

The graph from B generally increases with time while the graph from Part C generally decreases with time. Or, one graph seems to be almost the opposite of the other.

Similarities

Both show greater changes for the years up to 1950 and smaller changes for the years 1950 to 1965. There seems to be a leveling off in the later years in both graphs.

4. The darkened parts under the actual graph look very similar to the Life Expectancy Graph for Part B. This would seem to indicate that the death rate pattern is roughly opposite to the life expectancy pattern.

SELF-INSTRUCTIONAL ACTIVITY D

Patterns of Disease

In this part of the investigation you will study two patterns of deaths in the United States during the twentieth century: (1) deaths due to infectious diseases and (2) deaths due to non-infectious diseases. You will then compare these patterns with the life expectancy graph from Self-instructional Activity B.

1. Recall what you did in Self-instructional Activity C. If you want to compare deaths with life expectancy, what would be the best way to arrange the vertical scale when you graph the data?

2. The data table below lists deaths per 100,000 population for two kinds of diseases, infectious, such as typhoid fever and tuberculosis, and non-infectious, such as heart disease and cancer. Construct two graphs, one from each set of data.

YEAR	1900	1920	1930	1940	1950	1960	1965
Infectious Diseases	541	460	242	146	64	49	41
Non-infectious Diseases	587	561	591	655	614	689	677

3. Which of the two graphs is more similar to the life expectancy graph in Self-instructional Activity B?

4. Write a summary statement of your conclusions after comparing all of the graphs for Self-instructional Activities B, C, and D.

Expected Results

1. Since we wish to compare disease fatalities with life expectancy it would seem to be a useful technique to arrange the vertical scale (number of deaths) with the lower numbers at the top of the scale.

2. The graphs should be constructed in a manner similar to that in Self-instructional Activity C.

3. The graph of deaths from infectious disease is similar but opposite to the life expectancy graph.

4. Apparently the increase in life expectancy is mainly due to our ability to combat infectious diseases. Deaths from non-infectious diseases have actually increased as life expectancy has increased. Many of these non-infectious diseases are more prevalent among the elderly so that some increase in these deaths is to be expected as more people live to older ages, even though some progress has been made in controlling these diseases also.

Appendix A

WORKING HYPOTHESES

The Junior High School Science Curriculum

1. Make the program investigative.
2. Incorporate activities and points of view directly from nation-wide programs where appropriate.
3. Organize the program on a block approach as opposed to concentrating on a single discipline per year, but cover all three disciplines (Earth, Physical, Life) in the three-year sequence.
4. Incorporate social problems directly into the program; include sex education, alcohol and drug abuse, smoking education, and environmental pollutants.
5. Make specific provisions for the incorporation of developments in current science.
6. Provide program modifications and/or options to meet the needs of pupils with varying abilities.
7. Provide exciting options for highly able students and strictly limit biology in Grade 9 to those students planning to take college level courses at the 12th grade level.
8. Maintain a balance among the three types of goals: processes, concepts, and values.
9. Provide a story-line to give continuity from block to block.
10. Select content and activities relevant to the interests and developmental levels of the pupils.
11. Develop and supply laboratory manuals for each student; make available paperbacks and other references needed to implement the program.
12. Develop new equipment and refine existing equipment needed to implement the program.
13. Develop a teachers' guide to give detailed suggestions for using the laboratory investigations and other activities.
14. Provide appropriate in-service educational activities to implement the new program.
15. Provide flexibility to allow for individual differences and preferences of teachers, the introduction of pilot programs and other innovations, and the utilization of special resources within the local school environment.

16. Encourage pilot projects designed to evaluate modern educational techniques such as ITV, CAI, team teaching, and independent study.

Appendix B

THE CONCEPTUAL SCHEMES OF SCIENCE[1]

Science is one of the efforts of man to describe and relate with ever-increasing accuracy and simplicity, and to explain, the objects and events within our natural environment.

The Nature of Science

--- Science proceeds on the assumption, based on centuries of experience, that the universe is not capricious.

--- Scientific knowledge is based on observations of samples of matter that are accessible to public investigation, in contrast to purely private inspection.

--- Scientific knowledge is obtained in a piecemeal manner, even though scientist aim at achieving a systematic and comprehensive understanding of various sectors or aspects of nature.

--- Science is not, and probably never will be, a finished enterprise, and there remains very much more to be discovered about how things in the universe behave and how they are interrelated.

--- Measurement is an important feature of modern science, because formulation as well as the establishment of laws are facilitated through the development of quantitative distinctions.

--- Science is a process that involves two major features: (1) the systematic collection of data from observations of natural phenomena, and (2) the generating of imaginative ideas whereby the data can be shown to be logically interrelated.

The Nature of Matter

STRUCTURE

Matter is thought of as being composed of fundamental particles which under certain conditions can be transformed into energy and vice versa.

CLASSIFICATION

Matter exists in the form of units which are classified by scientists into hierarchies of organizational levels.

---

[1] Guidelines and Strategies for Science Curriculum Development, Second Draft, January 1968, pp. 33-35

PROBABILITY

The behavior of matter in the universe can be described on a statistical basis.

INTERACTION

Units of matter interact. Most interactions are caused by electromagnetic, gravitational, and nuclear forces.

EQUILIBRIUM

All interacting units of matter tend toward equilibrium states of minimum available energy.

MOTION

One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for the states of matter: solids, liquids, gases, and plasma.

CHANGE

All matter exists in time and space and, since interactions occur among its units, matter is subject in some degree to changes with time. Such changes may occur at various rates and in various patterns.

LIVING THINGS

Although living and non-living things exist within the framework of the same physical laws, living organisms have unique characteristics and capabilities. Among those that distinguish all living things are metabolism, growth, and reproduction; also, some living things show evidence of thought and self-awareness.

Appendix C

CHARACTERISTICS OF A SCIENTIFICALLY LITERATE PERSON[1]

The End Product of a K-12 Science Program

1. He has faith in the logical processes of science and uses its modes of inquiry, but at the same time recognizes their limitations and the situations for which they are peculiarly appropriate.

2. He enjoys science for the intellectual stimulus it provides, for the beauty of its explanations, the pleasure that comes from knowing, and the excitement stemming from discovery.

3. He has more than a common sense understanding of the natural world.

4. He appreciates the interaction of science and technology, recognizing that each reflects as well as stimulates the course of social and economic development, but he is aware that science and technology do not progress at equal rates.

5. He is able to derive conclusions from some of the major concepts, laws, and theories of science.

6. He understands that science is one but not the only way of viewing natural phenomena and that even among the sciences there are rival points of view.

7. He appreciates that knowledge is generated by people with a compelling desire to understand the natural world.

8. He recognizes that knowledge in science grows, possibly without limit, and that the knowledge of one generation "engulfs, upsets, and complements all knowledge of the natural world before."

9. He appreciates the essential lag between frontier research and the popular understanding of new achievements and the importance of narrowing this gap.

10. He recognizes that the achievements of science and technology can be basic to the advancement of human welfare, provided diligence is continuously exercised to direct science toward constructive rather than destructive processes.

---

[1] Guidelines and Strategies for Science Curriculum Development, Second Draft, January 1968, pp. 10-12

11. He recognizes that the meaning of science depends as much on its inquiry process as on its conceptual patterns and theories.

12. He understands the role of the scientific enterprise in society and appreciates the cultural conditions under which it thrives.

Appendix D

SUMMARY REPORT OF NSSA-WORKSHOPS ON BEHAVIORAL OBJECTIVES

Summary of Suggested Behaviors Reported Under Each Subtopic

A. Awareness of conditions
  1. relates personal requisite abilities, interests, and attitudes
    a. participates in extra curricular science clubs and fairs
    b. selects a science-related summer job
    c. given an attitude or ability check list, can relate himself to the list as to a possible career in science
  2. appreciates the interaction of science and technology
    a. joins Junior Engineering Technical Society (JETS) or a rocket club
    b. gets a summer job in an industrial laboratory
    c. discusses social problems in terms of the relationship of science and technology, including automation
    d. willingness to support scientific endeavors because eventual technological applications
    e. willingness to apply the scientific method to the solution of any problem
    f. attempts to build equipment based on a learned concept
  3. appreciates the interaction of science and the arts
    a. designs and carries out a science project which relates science to music or art
    b. composes music through computer programming
  4. appreciates the limitations of science
    a. limits conclusions to present data but verbally recognizes possibility of error
    b. willingness to retest in the face of seemingly conclusive data
    c. frequently challenges classmates or teachers who make authoritative statements, such as "science has proved ...."
  5. understands that science is generated by people with a compelling desire to understand the natural world
    a. shows interest in and respect for famous scientific biographies
    b. chooses a life vocation based on other than expected earning power
    c. selects a biography of a scientist to fulfill a book report requirement in another subject
    d. watches TV programs about scientists
    e. shows respect for the ideas of scientists
    f. recognizes that science is an enterprise of human beings

6. recognizes that science grows, possibly without limit (or: the processes of science lead to a never-ending quest for knowledge)
    a. realizes that controversies are inevitable in the process of growth
    b. evidences ability to live with change
    c. upon learning the results of a study, states additional possibilities to investigate
7. recognizes that the achievements of science and technology properly used are basic to the advancement of human welfare
    a. chooses a career of service in nursing, resource management, or other occupation utilizing science for human welfare
    b. supports taxes for community solution of pollution problems
    c. does not pollute air and streams, and practices conservation
    d. participates in mass inoculation programs
    e. supports public health agencies
    f. contributes to research
    g. has periodic physical and dental examinations
    h. volunteers services for community organizations
8. recognizes that the meaning of science depends as much on its inquiry process as on its conceptual patterns
    a. defines science as both a process and a way of explaining phenomena
    b. can select appropriate investigative strategies to the solution of a problem
    c. can identify and state a problem
9. appreciates the cultural conditions under which the scientific enterprise is promoted
    a. accepts the concept that the social and economic climate will support or discourage the scientific enterprise
    b. gives logical arguments for or against national policies for the planning of research
    c. writes to congressmen urging support of legislation in favor of scientific research

B. Acceptance of values
10. rejection of myths and superstitions as explanations of natural phenomena
    a. analyzes superstitions to see if they have scientific relevancy
    b. collects data to determine degree of reliability of common superstitions
11. has the habit of considered response

    a. volunteers recitation only when he has an organized relevant response
    b. retains questioning attitude to permit adequate consideration of possible options, and to permit a conscious plan of attack, clearly looking forward to a prediction of the probable outcome or solution
12. has the habit of weighing evidence to formulate a considered response
    a. habitually consults more than one authority in searching for explanations
    b. identifies assumptions made as the basis of his decision-making and then questions their validity
13. realizes that science is a basic part of modern living (some participants thought this should be deleted)
    a. comments on pseudo science in advertising media
    b. when asked to comment on the conditions of modern living, cites technological and scientific advances which lengthen life, shorten work week, etc.
    c. accepts science as human intellectual endeavor which contributes to our society

C. Preference for Values
14. curiosity
    a. frequently asks questions and challenges statements of others
    b. asks different people the same question
    c. applies multi-resources to one question
    d. often takes a second look
    e. goes out of his way to find answers
    f. reads numerous books and magazines
    g. habitually examines the working parts ofeequipment being used
    h. visits museums and industrial or food-processing plants
    i. initiates questions voluntarily
    j. exhibits awareness of discrepancies in his environment
    k. collects and orders the collection in some way
    l. includes reading about science and watching science based programs in leisure time activities
    m. uses all senses in making observations
15. patience
    a. is willing to wait for something worthwhile, i.e., data
    b. undertakes long-term projects where no immediate results are possible
    c. is willing to perform time-consuming procedures without attempting questionable shortcuts
16. persistence
    a. is willing to repeat an effort voluntarily

   b. redesigns experimental systems in an attempt to improve results

17. open-mindedness
   a. listens carefully when others are talking
   b. insists on hearing more than one opinion on one piece of evidence
   c. is willing to change ideas when new or additional evidence is available
   d. will give consideration to ideas which differ from his own

18. (deleted tolerance)

19. (deleted) (related to open-mindedness)

20. confidence in the scientific method
   a. follows instructions of doctor
   b. cleans out medicine closet periodically
   c. attempts to use scientific methods when making decisions.
   d. looks for data or evidence before acting
   e. consults and considers consumer reports
   f. votes for elected officials on the basis of available evidence

21. 'the search for truth'' (nothing reported)

22. the importance of science for understanding the modern world
   a. enrolls in science courses

23. (nothing reported) (the values of methods and procedures of science)

24. (nothing reported) (appreciates the men who add to the storehouse of knowledge)

25. intellectual satisfaction to be gained from pursuit of science
   a. engages in investigative activity during leisure time
   b. asks about and shares his observations of similarities and differences in his environment

26. (nothing reported) (the excitement of discovery)

27. the desire to be creative
   a. participates in research on his own initiative
   b. offers realistic alternatives to a presented method for doing something
   c. gets involved in independent study
   d. displays a variety of reactions or insights

28. (nothing reported) (faith in the logical process of science)

29. enjoys science for intellectual stimulus and the pleasure of knowing
   a. gravitates toward idea-exchanging activities

30. (nothing reported) (appreciates the importance of narrowing the gap between frontier research and the popular un understanding of new achievements)

Appendix E.

BEHAVIORAL VERBS[1]

1. Identify. The individual selects a named or described object by pointing to it, touching it, or picking it up.

2. Name. The individual specifies what an object, event, or relationship is called.

3. Order. The individual arranges three or more objects or events in a sequence based on some stated property.

4. Describe. The individual states observable properties sufficient to identify an object, event, or relationship.

5. Distinguish. The individual selects an object or event from two or more which might be confused.

6. Construct. The individual makes a physical object, a drawing, or a written or verbal statement (such as an inference, hypothesis, or a test of any of these).

7. Demonstrate. The individual performs a sequence of operations necessary to carry out a specified performance.

8. State a Rule. The individual communicates, verbally or in writing, a relationship or principle that could be used to solve a problem or perform a task.

9. Apply a Rule. The individual derives an answer to a problem by using a stated relationship or principle.

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[1] Verbs and definitions from Science, A Process Approach, the elementary program developed by the American Association for the Advancement of Science.